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# The Critical World Food Situation

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AS EARLY AS 1798 Thomas Robert Malthus in his Essay on Principle of Populations had the vision that "power of population is infinitely greater than the power in the earth to produce subsistence for man."[1] This statement has provoked controversies for over 150 years but still stands as a challenge for this and future generations to produce sufficient food for the ever increasing world populations. However, attempts at increasing food production are making significant progress, and this article will review these recent advances.

The population of the world has increased over three fold in the past 200 years, from 728 millions to 2,378 millions in 1950.[2,3] The number of people now living on the face of the earth is so large that even small rates of natural increase will result in an almost astronomical increment over periods of time of infinitesimal duration compared with the past history of the human race. Between 1920 and 1950, the population of the world is estimated to have increased at a rate of 0.9 per cent per year. A continuation at this rate of increase would result in a world population of 14.3 billions in two centuries and 35.4 billions in three centuries, or roughly the period which has elapsed since the pilgrims landed on Plymouth Rock.[4]

During 1938–48 the world population increased 8.3 per cent. However, during the same period the overall world-wide production of calories available for human consumption increased only 0.7 per cent, and that of total proteins by only 1.4 per cent.[5] In recent years the population of India has been expanding at the rate of about 40 million per decade, while food production has remained more or less stationary.[6] No country in which the people live close to the subsistence level can support an increase of population without an increase in food production of approximately the same order of magnitude.

Asia more than any other continent is the land of hunger. Asia makes up one-third of the land surface, but in it are concentrated two-thirds of the world's population. Throughout the Far East the undernourished segment includes more than 90 per cent of the population, while in Latin America more than 66 per cent of the people are ill-fed, ill-nourished, and ill-clothed. There is not a single country in South America in which the population is free of hunger. In Africa, the second largest continent of the world, within its 11,500,000 square miles (four times the size of the United States) live only 180 million people. Yet, with this vast territory at its disposal, the relatively scant population has been unable to escape the siege of hunger.[6]

The total food production of the world, based upon the 1952–53 figures (Food and Agricultural Organization of the United Nations,

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1953),[7] is estimated to have regained the pre-war level per head of the population. The provisional estimates for 1952–53 show an increase of 17 per cent over the pre-war average in both food production and population. But these figures of overall production and increases are misleading, since they do not reveal the unevenness of the increase. For instance, nearly half of the increase in world agricultural production since 1934–38 occurred in North America alone, a region which supports only 7 per cent of the world's population. At the other extreme, the Far East, which holds about one-half of the world's population, has only maintained its pre-war level of production. The unevenness of the present-day food production is associated with uneven rates of population increase, and hence uneven basic food requirements in many parts of the world.

Food consumption cannot be separated from purchasing power. In countries like North America, only about from 30 to 40 per cent of the wage-earner's income is spent for food; in the Far East most of the resources of the wage-earner are used to obtain a diet which, even then, is inadequate for himself and his family.

In the underdeveloped areas where population pressures are greatest, the most serious difficulty lies in the quality of the diet, which is characterized by a low level of protective foods. There is no relatively simple unit, such as the calorie, available for the measurement of the quality of diets. The protein content is perhaps the best available yardstick, because most foods rich in proteins are also comparatively good sources of other essential nutrients, especially vitamins and minerals. Because this is particularly true of foods of animal origin, the animal protein intake is a better indicator than the total protein intake.[7]

Of all the proteins ingested, only those of animal origin are considered good enough to be of superior biological value, but it takes two or more acres of land to graze a cow, if soil and moisture conditions are favorable. The availability of animal foods is further complicated by the cow being considered sacred in such an overpopulated nation as India, where it is used largely for power rather than for meat and milk. India has about half the cattle of the world but the poorly fed cows give little milk.[6] Foods of animal origin are also forbidden by large sects in the Far East who believe in the transmigration of souls.

"The conversion of vegetable calories [into animal tissue] has long been known to be inefficient, only 15 per cent of vegetable calories is recovered in producing milk, 7 per cent in eggs, and only 4 per cent in beef."[6] It is consequently impossible to raise sufficient cattle for human consumption in overpopulated and underprivileged countries. Plant foods of inferior biological value in proteins must necessarily provide sustenance for the greater portion of the world, and these are supplied by the cereal grains, legumes, vegetables, fruits (bananas in Central America) and such starch foods as cassava and manioc. Relatively small amounts of meat or dairy products are consumed in Asia, Africa, and the Latin American countries. Another handicap for the meat and dairy industries in the latter countries is the lack of refrigeration facilities. The high incidence of infections and low life expectancy (26 to 30 years in Asia and South and Central America) may well be related to a large extent to a low intake of high quality proteins and also, in certain regions, to inadequate supplies of vitamins and minerals.[6,8]

## PREVALENCE OF HYPOPROTEINOSIS[8]

### *Areas of High Protein Scarcity*

Phillips, in a review of the possibilities of expanding livestock production through the world, has listed the average intakes of vegetable and animal protein per capita in 58 countries.[9] Using the arbitrary figure of 30 grams of animal protein per day as a desirable intake, he notes that this level is equalled or exceeded in only 18 of the 58 countries. Extreme shortages of high quality protein, sometimes in conjunction with a deficiency of total protein, are common in the Far East, Africa, Central America, the West Indies, and parts of South America and Europe. It is in these areas that the signs of hypoproteinosis abound, including retarded growth, high child mortality, inferior adult size and strength, and low resist-

ance to tuberculosis and other infectious diseases.[10] Here, too, the gross visible effects of faulty nutrition are frequently seen, including cheilosis, angular stomatitis, glossitis, skin ulcers, nutritional edema, pellagra, and kwashiorkor.[10–12]

## HOW TO IMPROVE THE WORLD FOOD SITUATION

(1) *By Proper Food Combinations.* The world's food supply is dominated by cereals, the most economical source of fuel requirements for the human race. About 80 per cent of the world's population belong either to the "rice" or "wheat" eating worlds. Rice has always been the food of the yellow and brown races, while for several centuries, wheat, through preference, has been the universal grain of the white race. The dense population of the southeastern portion of the Asiatic continent and adjoining islands from India to Japan use rice largely for their sustenance. There the warm climate and abundant rainfall provide an ideal growing environment for the rice plant, and the bulk of the world's rice growing and rice consumption is in these regions. The "wheat world" includes northwestern Europe except the Scandinavian countries, southern Europe, Canada and the United States in North America, the southern part of South America, Australia, New Zealand, and parts of North China. The "rice world" is thus more compact geographically than the "wheat world" and somewhat larger in numbers of human inhabitants.

The percentages of total daily calories derived from cereals before World War II reported in 1937 by the Mixed Committee of the League of Nations for different parts of the world are as follows: United States, 34; United Kingdom, 35; Germany, 39; France, 55; Italy, 64; Russia, 73; and Japan, 87. In southern China rice provides more than 75 per cent of all food calories, while in northern China wheat constitutes the main cereal.

The proteins in cereal grains are of low biological values compared with those of animal origin,[13,14] because they are deficient in certain essential amino acids. It has been known for many years that the proteins of wheat are deficient in lysine and that the proteins of corn are deficient in tryptophan as well as in lysine.[15] In 1951 Pecora and Hundley reported on the nutritive improvement of white rice by addition of lysine and threonine.[16] The author has since demonstrated that threonine is an amino acid deficient in the proteins of wheat,[17] corn,[18] rye,[19] and barley.[14]

Compared in the mature dry state, the legumes are about twice as rich in protein as the cereal grains. The soybean is outstanding for its high protein content (50 to 52 per cent in the defatted state) and for its nutritive value.[20] Since it is high in lysine,[13] an attempt was made to supplement the proteins in enriched milled wheat flour and milled white corn meal with small amounts of defatted soybean flour. In rations containing 84 per cent wheat flour furnishing 9.07 per cent protein in ration, the substitution of 1, 3, and 5 per cent soybean flour for equivalent amounts of wheat, resulted in 55.2, 108.3, and 192.4 per cent increased growth, respectively, and in 23.9, 45.5, and 60.2 per cent increase in protein efficiency ratio (PER), expressed as gains in body weight per gram of protein intake. In a ration containing 89 per cent corn meal furnishing 7.48 per cent protein in ration, the substitution of 1, 3, and 5 per cent of the soybean flour for equivalent amounts of corn meal, was followed by 86.0 172.4, and 270.7 per cent increased growth, and by 46.8, 70.9, and 95.0 per cent increase in PER, respectively.[21] Marked supplementary values to the proteins in milled wheat and corn meal were also found by additions of small amounts of such high protein-containing foods as dried nonfat milk solids, dry buttermilk, brewer's and cultured yeasts, and peanut flour.[21]

Corn is a significant cereal grain for human consumption in the southern part of the United States, Guatemala in Central America,[22] South Africa, Yugoslavia, and Mexico,[23] but its proteins have a very low biological value, being deficient in the amino acids lysine, tryptophan, methionine, threonine,[18] and isoleucine.[24] Because the proteins in milled rice were found to be much superior to those in milled corn and wheat,[25] the possible supplementary relationships among these proteins were investigated on albino rats.

When half of the proteins in milled *corn* meal was replaced by proteins in milled rice, there was a 236 per cent increase in body weight and 165 per cent increase in PER. When one-third of the proteins in corn meal was replaced by proteins in milled rice, there was a 190 per cent increase in growth and 148 per cent increase in PER. When half of the proteins in milled *wheat* was replaced by an equivalent amount of proteins in milled rice, there was a 114 per cent increase in growth and 86 per cent increase in PER, and when one-third of the proteins in wheat was replaced by proteins in milled rice, there was 55 per cent increased growth and 55 per cent increase in PER.

*It would seem most desirable for people of low income level now using milled corn for their basic cereal foods to consume a greater proportion of rice to balance the deficient proteins in corn.*

(2) *By Amino Acid Enrichment.* In 1953 the author was able to change the protein efficiency of milled wheat flour from 0.68 to 3.11 by amino acid supplementation. On the same nitrogen intake with the added amino acids lysine, valine, and threonine, the proteins in patent wheat flour used for baking bread were improved to the extent that they had 94 per cent of the efficiency of the proteins in dried nonfat milk solids (skim milk).[17] If the cost of commercially produced amino acids can be made sufficiently reduced, the human application of the results of this study could conceivably constitute a significant contribution toward improved nutrition for poorly fed population groups.[17,27] In this connection, the following comments have appeared in a recent issue of *Nutrition Reviews*[26]: . . . "One of the major reasons for the ultimate success of such measures is the fact that there is no necessity to change, through education or force, the food habits of individuals, which often are so irrevocably dictated by custom, agricultural production potentialities and economic circumstances."*

Amino acid enrichment of milk has been reported by Albanese and associates.[28] Anorexia associated with underweight in infants responded to lysine supplementation when evaporated or fresh milk formulae were fed. The biochemical effects of the lysine supplements were determined in terms of anthropometric and body weight changes, nitrogen balance, hemoglobin, total plasma protein, and blood lysine levels. The supplement was given as L-lysine HCl at the rate of 100 mg of lysine/kg/day. A supplement of lysine for infants' milk formulae is now available in this country. Geriatric foods offer another potential market.[27]

(3) *By a Modified System of Agriculture.* According to Martin and Leonard,[29] the climatic requirements for the *soybean* are about the same as those for corn. Soybeans will grow in nearly all types of soil, but they are especially productive on fertile loams. They are better adapted to low fertility soils than is corn, provided the proper nitrogen-fixing bacteria are present. It would appear, therefore, that the world food situation would be materially bettered and the nutritional status of underdeveloped, overpopulated, and malnourished countries would be materially improved, if a crop rotation between corn and soybeans were practiced to a much greater extent than in the past wherever possible.

Recently the proteins in whole *rye* (pumpernickel) flour were found to be twice as efficient as the proteins in whole wheat flour.[14,19] The amount of rye grown in the United States is very small, the average annual production being about 37,400,000 bushels, compared with 3,306,000,000 bushels for corn and 1,291,000,000 bushels for wheat.[29] The leading countries in rye production are Russia, Germany, Poland, Czechoslovakia, France, and Hungary. Rye is more productive than other cereal grains on infertile, sandy, and acid soils, and is adapted to colder climates.[29] Millions of poor, unproductive soils in the world could be converted to rye cultivation, which could be used advantageously both for human consumption and for feeding of livestock.

The author has recently found that the proteins in *buckwheat* at an 8 per cent level of protein intake are the best known source of high biological value proteins in the plant kingdom, having 92.3 per cent of the value of the proteins in dried skim milk, and 81.4 per cent of the

* Lysine-enriched bread is already available on the market in certain regions of this country.

value of the proteins in dried whole eggs. The proteins in buckwheat also have significant supplementary value to the proteins in cereal grains and in grain sorghum.[30] Buckwheat in general is an exceptionally good crop for poor soils and can be grown where wheat or even rye cannot be grown with profit. The average production of buckwheat in this country from 1937 to 1946 was only 7,000,000 bushels,[29] and its use is limited in this country to griddle cakes with syrup or honey. In Central America buckwheat flour is used in the preparation of "tortillas," "tamales," pancakes, and similar cereal-containing foods. It is also used with wheat flour up to 25 per cent in baking of bread. In general, buckwheat flour is used like wheat flour in all pastries which do not require yeast.[31] The results of these studies would indicate the desirability of much further expansion of buckwheat cultivation in the Orient, Latin American countries, and in areas of Africa.

(4) *By the Use of a Low-Cost High-Protein Low-Calorie Food.* A processed food, which is low in cost, high in protein, but low in calories has been described.[32] It is composed largely of defatted soybean flour, significant amounts of dried nonfat milk solids, some roughly ground hard whole wheat, vegetable oil, salts, water, and is spiced with a hydrolyzed plant protein containing reduced monosodium glutamate. Needed vitamins and minerals may be added at little cost. This food blends well not only with ground beef, ham, chicken, and fish, but also in prepared foods with vegetables and cereal grains, particularly corn meal and cooked rice.[32]

(5) *By the Use of Leaf Crops as a Source of Proteins.* The extraction of nutritious materials present in leaf crops, which are now considered to be inedible, has been studied. The separation of the fluid cell contents of starch, fat, leaf proteins, sugars, and other components of low molecular weights has been carried out on a laboratory scale with varying success for over a century. Several attempts have been made during the last decades to accomplish this on a commercial scale. The greatest need appears to be a machine which is capable of efficiently pressing the nutritious juice from the ground mass of leaves. Details of the designs of machines used by Pirie have been described.[33] The juice, after coagulation, gave a fluid containing sugars, amides, amino acids and salts, and also a coagulum containing proteins, fats, and sugars. The fibrous mass contained most of the cellulose, lignins, and pectins and some remaining proteins, starches, and fats. The value of this pressed fiber residue as an animal feed depends on the extent to which the protein has been removed. When the crop was simply ground and pressed, the dried residue generally contained from 1.5 to 2.0 per cent nitrogen. Thus, it has a feeding value similar to that of good hay and is more economical to dry than grass. Initial analysis of the amino acids present in the fluid[34] suggests that the leaf proteins may be capable of supplying human requirements. In the past, insufficient recognition has been given to the fact that young, vigorously growing leaves of many plants have 30 to 40 per cent protein and little fiber. The interesting observation was made that leaves grown in partial shade have a higher protein content than leaves of comparative size, grown under the same conditions in open sunshine. The production of such protein-rich crops would do a great deal to revolutionize the world feeding situation.[35] In this connection, it may be mentioned that dehydrated vegetables, now used mainly in this country in the manufacture of spices and canned soups, in small amounts proved efficient as supplements to the proteins in milled wheat flour and corn meal. The improvement was so marked that this type of fortification in overpopulated countries could prove desirable.[36]

(6) *By the Use of Food Yeasts as Supplements to the Proteins in Cereal Grains.* Block[37] has found brewer's and cultured food yeast proteins to be complete from the standpoint of composition of amino acids. Eight commercially available yeasts have been analyzed for arginine, histidine, lysine, tyrosine, tryptophan, cystine, methionine, threonine, leucine, isoleucine, and valine, under highly comparable conditions. The *Saccharomyces cerevisiae* strains of yeasts are especially valuable food supplements in dietaries where cereal grains furnish

all or almost all of the dietary protein.[37] That this concept is quite correct has become apparent from subsequent publications.[38,39,40] The inclusion of nonviable, debittered, dried brewer's yeast in white bread markedly increased the nutritive value, even in the presence of 1 and 3 per cent of dried nonfat milk solids. As determined by rat growth, food utilization of breads with 1 and 3 per cent dried yeast was increased from 9.2 g gain per 100 g of food intake to 12.3 and 14.7 g, respectively.[41]

During World War II, large quantities of brewer's yeast were salvaged for animal and human consumption. In 1945 approximately 10,868,000 pounds of brewer's yeast were dried, of which 2,509,000 pounds were debittered to be used as nutritional yeast. In addition, about 5,700,000 pounds of primary grown (cultured) yeasts were produced in the United States for nutritional purposes.[42]

From a pure cultured yeast isolated under the microscope, 25,000 pounds of yeast are obtained in 72 hours. The significance of this is that more yeast proteins can be produced per acre of land, if the necessary sugars are available, than any other protein food which can be grown on the richest soil under ideal weather conditions and with the cheapest labor.[38]

Food yeasts of the Torula strain are now being produced economically from wood sugar stillage[43,44,45] and from potato starch wastes.[46] Ritzman[47] reported that dried wood yeast is equal to soybean meal as a protein supplement for production of milk by lactating cows. The food yeasts are also excellent sources of the vitamin B complex.[40,42,48]

(7) *By the Use of Algae as Possible Food Extenders.* It has been estimated that about 400 billion tons of sugar are produced annually by the plants of land and sea as primary products of photosynthesis.[49] Of this enormous amount, 90 per cent is synthesized by marine and fresh water algae and the rest by land plants. Of the latter, forests produce the bulk, about 67.5 per cent, while cultivated areas yield 24.5 per cent.[50] However, the primary products of photosynthesis are rapidly converted into other plant products or used as energy sources by the producing plant, while only a small part of primary photosynthetic products remain as such or are transformed into substances which animals can digest. Thus, it is not surprising that all the animals on earth, large and small, have been estimated to consume only 2 per cent of the products of photosynthesis of land plants. The entire human race uses for food, clothing, fuel and structural material, only 0.2 per cent of all the plant matter produced annually.[51] Weiss[52] in a recent paper on "Food for Tomorrow" raises the question of how can it be explained that man, though often in dire need, uses so little of the potential wealth that vegetation provides in such extravagant and wasteful manner? What is the reason that regions with the most prolific plant growth, such as the tropical rain forests, have the poorest levels of human nourishment? In these regions the annual production of vegetable matter has been estimated as high as 80 tons per acre,[53] as compared with 2.5 tons yearly accretion in the forests of the temperate zone, and 5 to 6 tons per acre of whole plants of high yielding hybrid corn.[54] A major factor in these situations is found in the conversion of photosynthetic matter into indigestible structural tissue of no nutrient value for the higher animals and man. The extreme example is wood, containing an average of 60 per cent cellulose, 30 per cent lignin, and 10 per cent hemicelluloses,[55] and with a nitrogen content as low as 0.1 to 0.3 per cent,[56] indicating the almost complete absence of protein. Another part of the answer is evident from the exorbitant rate of decay of plant material and the rapid conversion of plant débris into mineral and gaseous products through the action of heterotrophic organisms, such as bacteria and fungi, whose life processes are greatly stimulated by heat and moisture.[57]

Much has been written recently about algal culture, particularly regarding production of the unicellular green algae, *Chlorella*. Many of the reports deal with *Chlorella* as a source of food, while others discuss or recommend its use as a feed, fertilizer, or fuel. Research emphasis on algal culture stems from the fact that algae are very efficient users of solar energy and therefore, highly efficient photosynthesizers. The growth of algal culture requires a supply of

carbon dioxide, inorganic nutrients, a relatively uniform temperature, and light. Large scale culture as well as continuous harvesting of *Chlorella* appears technically possible but is still economically prohibitive.[58]

The algae, popularly known as seaweeds, are divided into four groups, the brown, red, green, and blue-green. The brown and red algae are the most important, partly because of the nature of the materials they contain and partly because they occur in sufficient quantity to possess an economic value. In the East, seaweeds form an important constituent of food supplies. In Japan seaweed is said to provide 25 per cent of the daily diet. The brown algae are incorporated in the flour and are used in almost every household as noodles, toasted and served in rice or soup. Two species, *L. japonica* and *L. augustata*, because of their high content of mannitol and glutamic acid, are used for sweetening and flavoring. In the West, seaweeds have never really been accepted in the diet and have only been eaten in times of scarcity and where the standard of living has been low. However, in Scotland, *Porphyra* (red algae) is still eaten. Grilled on toast, it looks like spinach and tastes like oysters and is made into *laverbread*, the national dish of South Wales. For centuries the red algae have been used in small quantities in the food industries. *Porphyra laciniata* used to be eaten as a vegetable with vinegar and pepper under the name of "laver" in Wales, "sloke" in Ireland, and "slack" in Scotland. The brown algae contain from less than 1 to 9 per cent fat. The mineral content varies from 10 to as high as 50 per cent. In a balanced diet they may prove to be an excellent mineral supplement, as they contain all the mineral elements essential for man. Seaweeds are also an important source of vitamins and appear to be similar to green vegetables in their vitamin content.[59]

An interesting preliminary study by Morimura and Tamiya in Tokyo, in co-operation with the Carnegie Institute of Washington,[60] demonstrates that palatable human foods can be made containing varying amounts of *Chlorella* powder. This product was used to enrich the following foods: French bread, 5.9 per cent; rolls, 10 per cent of the flour; noodles, 2 to 6 per cent; Japanese style green tea, up to 20 per cent; and ice cream, 9.9 per cent. The foods prepared in this manner were said to be "tasty" and "agreeable" as determined by several Japanese and American adults. Such foods also had what was described by the authors as an "agreeable" light green color. Various soups, both Japanese and Western styles, as well as a substitute for soy sauce, were also successfully prepared using *Chlorella* cells. The *Chlorella* cells contained 5000 I.U. of vitamin A (as carotene) and 2 to 5 mg of ascorbic acid per gram of dry weight by direct analysis. Information is lacking, however, on the efficiency of the proteins of algae and their biological value as supplements to the proteins in cereal grains.

(8) *By Increase in Fish Farming.* At the present time, fish and shellfish are believed to contribute about 2 per cent of the total food consumption of the world's human population. Of this amount, approximately 90 per cent is taken from the water of the northern hemisphere, while the far larger ocean expanses of the southern hemisphere have been essentially untouched.[61] Since more than 71 per cent of the earth's surface is water-covered, and an acre of sea is estimated to produce three times as much as an acre of land, these relatively untapped food reserves deserve careful research to determine the best means of utilization. It has been estimated that the total photosynthetic activity of the sea is about ten times that of all wild and cultivated plants on land. In addition, marine harvests require no labor or expense for tilling, irrigation, or fertilization. They are produced in a complete nutrient solution which contains not only all the essential mineral elements leached from the land masses through the centuries, but also large quantities of dissolved gases. (The oceanic content of carbon dioxide has been estimated at a million times that of the earth's atmosphere.) Yet this harvest of oceanic food has received little research to evaluate the potential role in world feeding.

One of the first tasks that confronted the Food and Agriculture Organization (FAO) of the United Nations was to institute a collec-

tion of statistics of world fisheries and to report them in summary form and uniform terminology.[63] The most recent Yearbook of Fisheries Statistics (FAO, 1953) covers the available information for 1950–1951. These data include all material furnished by national governments and conservative estimates of the yields of subsistence and sport fisheries for which exact figures are not available.

For centuries past, the Indonesian rice cultivator has practiced fish farming, as a sideline, "planting" baby carp in his flooded rice paddies at sowing time and "reaping" the grown fish when the paddy fields are drained for the rice harvest. In this way, at a minimum cost in money and effort he has supplemented his staple starchy diet of rice with the proteins necessary to maintain health. Today, this age-old practice promises to become an important factor in the modern world's search for means of increasing and improving the food supplies of the many malnourished millions. Playing a major role in this development is the expanded program of technical assistance being carried out by FAO and UNICEF (United Nations International Childrens' Emergency Fund), of the United Nations and its specialized agencies. On the island of Java, in Indonesia, fish farming is not confined to the rice paddies and inland waters. The brackish coastal marshes are also exploited by enclosing them within a sea wall and keeping them flooded with tidal waters. This method can easily be extended to the coastal swamps of any country, with the additional advantage that the fish are invaluable for controlling malaria because they live off mosquitoes. The experience in fish farming in Java is a demonstration of the fact that "know-how" is not the monopoly of the highly-developed countries. In effect, the simple cultivator of Java, where so many students are being sent on fellowships, is the "professor" of techniques of successful fish farming.[64]

## CONTRIBUTION OF FAO IN BETTERMENT OF WORLD NUTRITION

Historically speaking, the Food and Agriculture Organization of the United Nations has its roots in the science of nutrition. It, therefore, includes a Nutrition Division which works in collaboration with other FAO divisions: Agriculture, Fisheries, Forestry, Economics and Statistics, Rural Welfare, as well as the Nutrition Division of the World Health Organization (WHO). In 1950 the staff of the Nutrition Division consisted of 16 technical workers of 12 different nationalities. This Division is concerned with methods of collecting and analyzing food consumption data, chemical composition of foods, with specific measures for improving nutrition which are of proved value, one of which is supplementary feeding. The problem of increasing milk supplies is a closely associated one. Methods to improve nutrition through education is another of its important functions. The convening of periodic Nutrition Conferences and Committees in different regions of the world is an important activity. Two of these have been held in the Far East and two in Latin America. The Second Conference on Nutrition Problems in Latin America, held in Rio de Janeiro in June, 1950, was attended by nutrition workers from nearly all countries in the region. A third Conference by the Nutrition Committees was held in Bandung, Indonesia, in June 1953. In addition, Conferences by Joint FAO/WHO Expert Committee on Nutrition met in the Gambia in 1952, in association with a Conference organized by the Commission for Technical Cooperation in Africa South of the Sahara (CCTA in November 1953).[65]

The various functions and achievements of FAO and its associated agencies to date in the rehabilitation of underprivileged and overpopulated and malnourished countries in all parts of the world have been described in detail in the recent book by Hambridge.[66]

## BATTLE AGAINST KWASHIORKOR

Kwashiorkor is a disease which occurs in various parts of the world in infants and children, the primary cause of which is a diet abundant in starchy foods but deficient in adequate amounts of good quality proteins. The main clinical symptoms are failure of growth, retarded development, wasting of muscles, loss of appetite, mental apathy, edema, dyspigmentation of hair and skin, diarrhea, and pres-

ence of undigested food in the stools. Subcutaneous fat is often well retained. There may be signs of associated vitamin deficiencies. In the blood there is a reduction in the concentration of albumin and of certain enzymes. The characteristic pathologic findings are fatty infiltration of the liver and atrophy of the pancreas, together with a diminution in the amount of pancreatic enzymes in the duodenal juice.[67,68,69]

In Indonesia, edema is not a constant feature in children with other signs of the deficiency, but liver enlargement is usually found. In India, liver enlargement is a constant feature, but dyspigmentation of the skin and hair is not characteristic. In Indochina, what is described as a "violent malignant syndrome" occurs frequently among breast-fed infants. This syndrome is characterized by convulsions and carries a high mortality rate. The pathologic findings of protein malnutrition in countries of South and East Asia do not differ from that described in other parts of the world. However, mention should be made that in the so-called "boufissure d'Annam" the liver shows areas of necrosis in addition to steatosis.[67]

These protein-deficiency states are seen mainly in children in the weaning and post-weaning ages, the majority of cases being between the ages of 9 and 36 months. These states, however, sometimes occur as early as three to six months of age and are associated with earlier weaning. In general, in Oriental countries, infants when weaned are fed on rice gruel and no particular attention is given to feeding children with other foods to provide them with a "proper" diet. In Indonesia the majority of children with advanced protein malnutrition show signs of vitamin A deficiency, particularly xerophthalmia. In India, kerotomalacia, angular stomatitis, and cheilosis have been found in conjunction with protein malnutrition. Deficiency of vitamin A and ariboflavinosis have been found frequently associated with protein deficiency in the Philippines.

The nutrition of the mother plays an important part in the development of protein deficiency in infants. When the maternal nutrition is poor, there may be adverse effects before birth. There is some evidence that changes characteristic of protein deficiency, i.e., fatty infiltration of the liver, may occur in intra-uterine life, and lesions of the pancreas are found in premature and stillborn babies. Maternal malnutrition leads to premature reduction or cessation of the supply of breast milk. In many countries there are customs and beliefs regarding food for pregnant and nursing women which result in an unbalanced diet. These customs, and the ignorance of the mothers of proper methods of infant feeding, are other important causes of protein deficiency states among infants and young children. Brock and Autret[67] have discussed fully the syndrome of kwashiorkor as it occurs among African infants and children.

## POSSIBLE SOURCES OF PROTEINS FOR CHILD FEEDING IN UNDERDEVELOPED COUNTRIES[70]

It is recognized by FAO and WHO that the ideal diet therapy for infants and children suffering from kwashiorkor would be the provision of a generous supply of milk, but this is not practical in underdeveloped countries which have no dairy industry and which do not have the purchasing power to import dry milk from foreign countries to satisfy the nutritional needs of infants, children, and pregnant and nursing mothers. Moreover, for older infants and young children other protein foods besides milk are needed. The efforts to find other suitable protein-rich foods or combinations to prevent and cure protein malnutrition are of relatively recent date.

In Indonesia the population consumes soybean products in different forms, but they are not suitable for child and infant feeding and are of low keeping quality. It was found in India that a much more acceptable product from the standpoint of taste, flavor, and consistency, and which could be fed to infants and children, could be manufactured by adding some groundnut milk (from peanuts) to "soymilk."* The idea of using soymilk is not new. There are small, private soymilk factories in

* An aqueous extract from soybeans coagulated with magnesium chloride or other salts.

Hongkong and Manila. In Ohio a factory produces soymilk powder and other soy protein products for infants and children who are allergic to milk.

In 1952 Dean[71] reported the successful treatment of about 20 small children in Uganda suffering from kwashiorkor with an emulsified mixture of whole soybeans, bananas, and added vitamins. Sometimes maize flour was added, and sometimes dehydrated soymilk was substituted for soybeans. These experiments proved that the soybean-banana combination was an excellent one, but it should be realized that this "enriched" mixture can only be prepared satisfactorily in well controlled institutions and hospitals.

The FAO feels that more emphasis should be laid on the use of oil presscakes, by-products of the oil industry, which are such a valuable source of proteins at low cost. In Africa, FAO is encouraging industrialists to manufacture a presscake, the proteins of which would not be damaged during processing, which could provide, through sifting, a flour acceptable to children. The FAO is aiming to educate mothers to use such a flour in the preparation of the "sauce africaine," which is in itself a complicated food served with the basic starchy foods like millet, maize, rice, or manioc, and also to use this flour directly in the preparation of the millet, maize, and manioc paps which they give their children. Various other experiments have been made: for example, peanut "milk" has been given to children 4 to 6 months old who have previously been receiving only breast milk and whose growth curves were no longer satisfactory. An industrialist in Nigeria is preparing a slightly roasted sifted flour from presscake, which, either salted or sweetened, is well accepted. Several flour factories in Belgian Congo, Nigeria, and French West Africa are now actively engaged in the processing of such products suitable for human consumption. Without having the same supplemental value as certain other protein sources, the peanut presscake would certainly largely contribute to the improvement of the diet in underdeveloped countries. The cost of this product is at present 8 cents a kilogram or about 3.6 cents a pound.

WHO and FAO have also been interested in infant and child feeding problems in the Near East, especially in connection with the Arab refugees. It was found that combinations of *burghul* (parboiled wheat), *homos* (chicken paste), and *leban* (sour milk) could substitute for more expensive infants' foods.

Another product to which FAO had drawn the attention of nutritionists, biochemists, and governmental authorities is *edible fish flour* containing up to 75 to 80 per cent protein of high quality. For the purpose of child and infant feeding, a cheap fish meal seems to offer great advantages in price and storage, in comparison with canned fish or the dried and salted product. It became apparent that in a number of countries a flavorless fish flour would be preferred, whereas in a number of other countries, such as in Southeast Asia and Africa, fish flour with certain flavors might be preferred.

Chile has large fisheries resources which are only partly exploited. The "fish consciousness" of the population and authorities of Chile is very high and, therefore, the FAO is making very good progress with fish flour in that country. Beet leaves pie, crackers (25 per cent fish flour), coffee cake (10 per cent fish flour), and bread (10 per cent fish flour) were unanimously accepted. Based upon these preliminary results, a large-scale trial was started involving 140 school children, 5 to 14 years old, who every day during six weeks, as part of their school lunch each received an 80-gram bread roll made at a commercial bakery, which used flour containing 10 per cent fish flour. Compared with normal bread, the only difference was a slightly darker color, the smell, taste, form and consistency of crust and crumb being normal. The bread was very well accepted by the children. There was not a single rejection or complaint, and no digestive trouble traceable to the bread occurred. The same type of fish flour-fortified bread was given to young men in a military camp. Here also this type of bread was very well accepted. After these results had been obtained, the Chilean Government requested UNICEF and FAO to help them in setting up a plant for the manufacture of edible fish flour to be used

mainly in supplementing feeding schemes. In the meantime, a great number of nutritionists and government officials all over the world have become interested in the great possibilities of edible fish flour, and UNICEF and FAO are arranging for a series of acceptability tests in different countries in co-operation with local fisheries and nutrition authorities.

In Africa several experiments are in progress and interesting results have already been reported. Experiments on infants have been carried out in Dakar under careful medical control with fish flour prepared from fresh fish fillets. The preliminary results show that fish flour can be given to very young children, as early as 3 to 4 months old, that is, as early as mixed feeding starts, provided the fat content is not higher than 3 per cent. When the fat content reaches 5 per cent, the fish flour is still well tolerated by infants of more than 6 months old. Fish flour with more fat (7 to 8 per cent content) was still acceptable to children between 1 and 2 years old.

## CONCLUSION

The late eminent biochemist, H. A. Mattill, stated that "the world cannot long exist in peace, if half its people are well fed and the rest ill fed." Hunger brings discontent and revolutions. Vandalism and even murder may be committed for a handful of rice or beans when a person is starving.[6] Perhaps we may look forward to the best prospects of establishing peace in the world from the concerted efforts of the Nutrition Committees of the Food and Agriculture Organization, the World Health Organizations, and their various agencies, which are working so intensively and efficiently to make available adequate supplies of high quality foods to the malnourished and overpopulated nations of the world.

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### *Problems of Food Supply*

"The world's population is increasing at a rate which renders distress, famine and disintegration inevitable unless we learn to hold our numbers within reason. New methods of extending the food supply, powerful though they may be, can only postpone the crisis, and perhaps allow time for communication and education to produce the general understanding that is essential to a sound solution of the underlying problem. There is no doubt that we can go far in providing new means of sustenance for great masses of people. The cultivation of that enormous reservoir, the sea, can yield richly if we learn to control organisms and species; and our land is far from exhausted if we learn to use it well. The transformation from a hunting and gathering culture to a culture dependent on herding and agriculture permitted a manifold increase of population and a simultaneous increase in physical welfare, and this could happen all over again and postpone temporarily the catastrophe predicted by Malthus. The process production of foods is just beginning. An understanding of photosynthesis and the creation of its synthetic equivalent could unlock stores of vital materials beyond our present power to envisage. Our control and training of natural species and the creation of new species at will for explicit purposes, especially species of lower organisms, hold enormous possibilities. And all this depends on our progress in understanding life itself, which is the subject of fundamental biology."
—Vannevar Bush. *Report of the President of the Carnegie Institution of Washington*, December 9, 1955, p. 5.

# The Effects of Supplementary Calories on Nitrogen Storage at High Intakes of Protein in Patients with Chronic Liver Disease

*By* IRVIN C. PLOUGH,* FRANK L. IBER,† MARGARET E. SHIPMAN,‡ AND THOMAS C. CHALMERS §

A DIET RICH in protein has an established place in the treatment of cirrhosis of the liver.[1] Successful therapy is accompanied not only by the return of altered liver function tests toward normal, but also by restoration of depleted protein tissue. Of the latter changes, the rebuilding of wasted musculature is perhaps the most obvious sign. The measurement of overall changes in body protein is best accomplished in short-term studies by determination of the nitrogen balance. The attainment of a large positive balance may thus reflect improvement in a patient with cirrhosis, although the liver function tests may be relatively static.

It has recently been observed that dietary nitrogenous constituents are not always beneficial in patients with severe liver disease. A high level of dietary protein may sometimes, in fact, initiate hepatic coma.[2] Impending coma thus produced can occasionally be reversed by reduction of the dietary nitrogen intake. Such reduction is accompanied by decreased nitrogen retention as measured by the nitrogen balance technique.

It might be possible to maintain a large positive balance of nitrogen in such patients at a lower, safer level of dietary protein intake by taking advantage of the protein-sparing effect of extra carbohydrate or fat calories. The present study was designed to measure the amount of nitrogen spared by large supplements of carbohydrate or fat in three patients with liver disease receiving adequate diets supplying moderate to large amounts of protein.

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## METHODS AND PATIENTS

The subjects of the present study were three men suffering from chronic liver disease. Patient 1 had severe cirrhosis with ascites; patient 2 had mild asymptomatic cirrhosis. The diagnosis in patient 3 was portal vein thrombosis. Case summaries are given below.

*Patient 1* was a 44-year-old white Army corporal who was hospitalized for progressive abdominal enlargement six months before study. He had imbibed liberally of beer and whiskey for 12 years and at the time of admission had massive ascites, spider angiomata, splenomegaly and a palpable liver. The serum albumin was 2.7 g and the total protein was 6.8 g per 100 ml. The sulfobromophthalein retention was 40 per cent. A roentgenogram after a barium swallow revealed varices of the lower one-third of the esophagus. The patient was treated with a low salt diet and occasional mercurial diuretics which controlled the ascites in the subsequent year.

*Patient 2* was a 36-year-old white mess sergeant who became ill in December 1953 with nausea, vomiting, and anorexia, followed shortly by jaundice. The diagnosis of infectious hepatitis was made. He improved in the subsequent six months on conservative therapy but abnormal sulfobromophthalein retention persisted and the liver remained enlarged. He drank five to six bottles of beer weekly. At the time of study, ten months after onset of the illness, the liver was palpable 6 cm beneath the costal margin, the spleen was not palpable, but spider angiomata were present. The total protein was 8.2 g per 100 ml, the albumin 3.6 g, and there was 12 per cent retention of sulfobromophthalein dye. Liver biopsy showed distortion of the lobular architecture.

*Patient 3* was a 23-year-old white airman who first noted anorexia, malaise, and jaundice in June 1953 and was found on examination to have a tender liver and splenomegaly. All symptoms suggesting hepatitis subsided, but splenomegaly persisted. Esophageal varices were present and repeated sulfobromophthalein tests showed retention of 10 to 16 per cent of the dye. Three liver biopsies showed only slight periportal scarring. Fourteen months after onset a laparotomy revealed extrahepatic portal vein thrombosis and a splenorenal shunt was performed. Three months after the shunt the esophageal varices appeared to be unchanged, but the pressure had diminished.

Nitrogen balance experiments generally took the following form: After a control period on a diet containing sufficient protein and calories to maintain positive nitrogen balance and a reasonably constant body weight, the diet was increased by 1000 calories of fat. In the following period carbohydrate was substituted isocalorically for the fat. In the last period the patients again received the control maintenance diet. The effects of carbohydrate or fat, or both, were studied in each patient at two or more levels of dietary protein. When the protein intake was raised the intake of non-protein calories was also increased by an amount equal to 50 per cent of the increment of protein calories to cover the specific dynamic action of protein. Potassium and sodium balances were also measured in four of the eight studies.

Throughout the experiments the patients were kept on a metabolic ward. Urine was collected under refrigeration for one- or two-day periods; stools for from two- to ten-day periods. Liquid diets of constant composition were employed. The main source of protein for patient 1, whose dietary sodium had to be restricted, was dialyzed milk protein*, for the other two patients skim milk powder was used. The carbohydrate sources were primarily lactose and sucrose; the fats used were butter and vegetable oil emulsion. Potassium was added to provide at least 150 meq per day. Each patient received a standard multivitamin preparation daily. All urine and stool collections, and weekly diet aliquots were analyzed for nitrogen by the macro-Kjeldahl method, and for potassium and sodium by flame photometry. Stool fat was measured in patients 1 and 2. In calculating the average balances during a particular period, the early days in a study period before steady excretion was reached were omitted. In the periods of caloric supplementation only the first two, or at most four, days were discarded. In measuring the effect of a supplement, the balance in the experimental period was compared with the average balance of both the pre- and postexperimental control periods.

In patient 2, skin-fold thickness was measured by the method of Brožek and Keys,[3] and body specific gravity was determined by underwater weighing.[4] Body fat was calculated by the formula of Rathbun and Pace.[5] Theoretical weights were calculated as follows: Each daily balance was corrected for the average balance in the initial control period, and the daily balances were accumulated. The cumulative balance of nitrogen multiplied by 32 is the theoretical weight change based on nitrogen (lean tissue), and the cumulative balance of sodium multiplied by 7.14 is the theoretical weight change based on sodium (extracellular fluid).[6]

Selected nitrogen balance data have been included here from eight patients, studied in this department for other reasons, in whom large changes of caloric intake were made without change in protein intake. *Patient 4* had moderately severe cirrhosis; *patient 5* was essentially normal. (Patients 4 and 5 are the same patients as P. S. and T. K. in Reference 7.) *Patients 6 through 11*, who were underweight, were in late convalescence from severe injuries. (They are the same as patients 3, 6, 7, 10, 12, and 13, respectively, in Reference 8.)

## RESULTS

There was no evidence of any change in the clinical state of any of the patients that could be attributed to the experimental procedures. The liquid diets, both the maintenance diets and those supplemented with large amounts of carbohydrate or fat, were well tolerated. The high fat diets caused no gastrointestinal symptoms.

* Largely Casec®, supplied by Mead Johnson and Company, Evansville, Indiana.

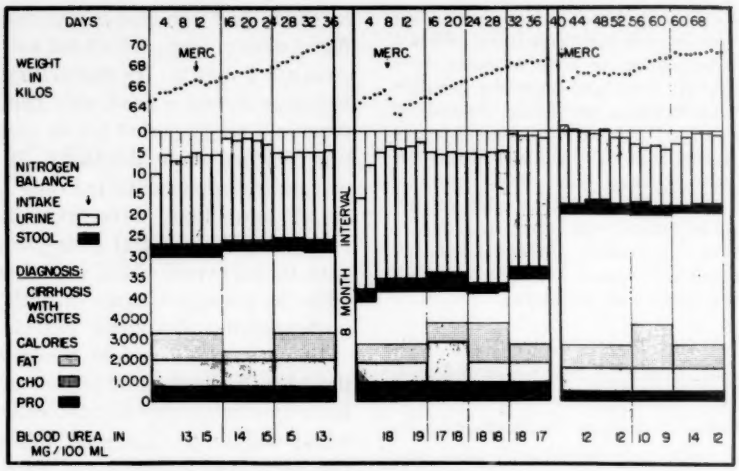


Fig. 1. Balance data from patient 1.

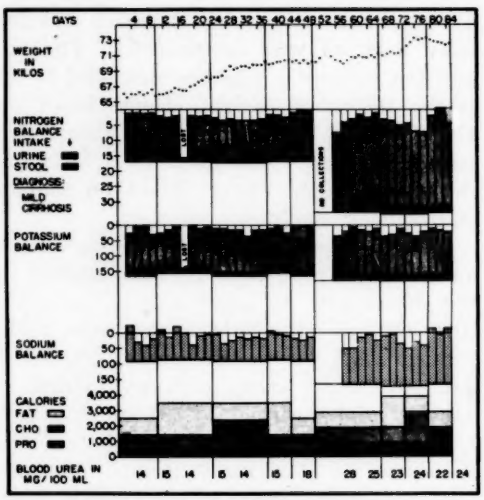


Fig. 2. Balance data from patient 2.

The caloric supplements spared nitrogen in every experiment (Figs. 1–3). The nitrogen spared, expressed as milligrams of nitrogen spared per added calorie, varied from 1.4 to 6.5 (Table I). Fat spared 1.4 to 4.0, and carbohydrate 1.4 to 6.5 milligrams of nitrogen per added calorie. In patients 1 and 3 the nitrogen spared by fat and by carbohydrate was approximately the same, but in patient 2 carbohydrate spared nearly twice as much nitrogen as did fat at both levels of nitrogen intake. In this patient, and also in patient 1, there were no significant differences in stool fat in the control, fat, or carbohydrate periods.

Potassium balances paralleled those of nitrogen, the ratio of potassium to nitrogen varying in the range of 4 to 8 meq per gram. In patient 2, the sodium balance was less positive than the control balance when the fat supplement was fed, more positive when the supplement was carbohydrate. No consistent change in sodium balance was noted in patient 3.

The amount of nitrogen spared by the supplements seemed to be directly related to the level of dietary protein intake. To confirm this point additional data were obtained in eight patients from studies done for other purposes in this department. In Figure 4 the nitrogen spared in milligrams per added calorie of fat, carbohydrate, or both, is plotted as a function of dietary protein intake in grams per kilogram of body weight, including eighteen studies on the combined eleven patients. It is apparent on inspection that good correlation exists. The correlation coefficient is 0.73, with a probability of less than 0.01. The formula for the regression line is $Y = 0.19 + 1.05X$.

## DISCUSSION

The range of nitrogen sparing found in these three patients with liver disease, 1.4 to 6.5 milligrams of nitrogen per added calorie, is

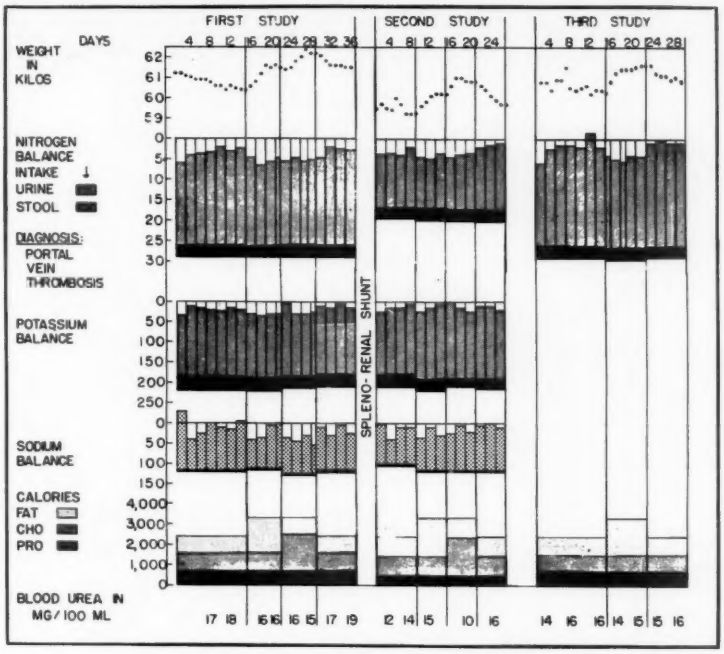


Fig. 3. Balance data from patient 3.

slightly higher than that listed in Munro's review,[9] where the range was 0.4 to 3.9, with a mean of 1.8, in experiments on man. From the present limited experience, it would appear that caloric supplements can spare nitrogen as well in patients with liver disease as in normal individuals. Therefore, if a high level of nitrogen storage is considered desirable in the treatment of chronic liver disease, large supplements of fat or carbohydrate can take the place of a certain amount of dietary protein in those patients to whom a high protein diet may be harmful.

The increase in the magnitude of the protein-sparing effect of added calories with increase in the level of dietary protein has not previously been reported. This relation may be a partial explanation for the variations in the figures collected by Munro.[9] The small protein-sparing effect seen in an individual receiving a low protein diet may be explained as follows: An irreducible minimum certainly exists in nitrogen excretion. When an individual's nitrogen intake is reduced to this level or less while his energy requirement is provided, extra calories could not affect his nitrogen balance. The explanation of the continued increase in nitrogen sparing with increasing protein intakes must await a general elucidation of the mechanism of nitrogen sparing.

Ingested calories above the energy requirement are stored as fat. Keys and Brožek[10] point out that body fatty tissue contains supporting structure (protein, water, etc.) averaging 38 per cent by weight. Such fatty tissue would contain 1.1 per cent nitrogen. It may be calculated that for each calorie stored as fat, 1.8 milligrams of nitrogen must also be stored. As mentioned above, this is the mean value of protein spared per added calorie in Munro's compilation of data from man. Although the hypothesis that the nitrogen-sparing effect of surfeit carbohydrate represents the formation of fatty tissue[7] is a reasonable one, it cannot be considered complete in view of the finding that the magnitude of nitrogen sparing depends on the level of protein intake. Indeed, values of 5 milligrams of nitrogen spared per added calorie (Fig. 4) are consistent with the formation of lean body

TABLE I

Changes in Nitrogen Balance Produced by Large Supplements of Carbohydrate or Fat Added to a Maintenance Diet

| Patient and study | Maintenance diet | | Caloric supplement | | Nitrogen balance | | | Mg N spared per added calorie | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Protein | Calories per kg | Calories | Type | Pre-control period | Experimental period | Post-control period | Fat | CHO | Both |
| | g/kg | | | | g/day | g/day | g/day | | | |
| 1A | 3.0 | 40 | 900 | Fat | — | 5.4 | 2.1 | 3.5 | — | — |
| | | | | | 2.1 | 5.1 | — | | | |
| B | 4.0 | 45 | 1000 | CHO | 3.3 | 5.3 | — | 2.8 | 3.0 | 3.0 |
| | | | 1000 | Fat | — | 5.1 | 1.2 | | | |
| C | 2.0 | 45 | 1000 | Fat | 0.7 | 4.0 | 1.0 | 3.2 | — | — |
| 2A | 1.5 | 37 | 1000 | Fat | 1.0 | 2.0 | — | 1.4 | 2.8 | 2.1 |
| | | | 1000 | CHO | — | 3.4 | — | | | |
| | | | 1000 | Fat | — | 2.0 | 0.1 | | | |
| B | 3.0 | 41 | 1000 | Fat | 1.6 | 4.2 | — | 3.6 | 6.5 | 5.0 |
| | | | 1000 | CHO | — | 7.2 | −0.4 | | | |
| 3A | 3.0 | 40 | 900 | Fat | 2.8 | 5.7 | — | 3.3 | 2.7 | 3.0 |
| | | | 900 | CHO | — | 5.1 | 2.6 | | | |
| B | 2.0 | 40 | 900 | Fat | 3.6 | 3.8 | — | 1.9 | 1.4 | 1.7 |
| | | | 900 | CHO | — | 3.4 | 0.6 | | | |
| C | 3.0 | 40 | 900 | Fat | 0.8 | 4.3 | 0.7 | 4.0 | — | — |
| 4 | 1.0 | 21 | 1000 | CHO | 2.1 | 3.5 | — | — | 1.4 | — |
| 5 | 1.2 | 36 | 1000 | CHO | 1.3 | 2.3 | — | — | 2.2 | — |
| | | | | | — | 2.8 | −0.8 | | | |
| 6 | 1.8 | 47 | 1000 | Both | 3.9 | 4.6 | 1.5 | — | — | 1.9 |
| 7 | 2.0 | 50 | 700 | Both | — | 5.4 | 4.2 | — | — | 1.7 |
| 8A | 2.2 | 47 | 800 | Both | 5.3 | 6.8 | — | — | — | 1.9 |
| | | | | | — | 2.6 | 1.1 | | | |
| B | 1.6 | 43 | 1000 | CHO | 2.2 | 4.1 | — | — | 1.2 | — |
| | | | | | — | 5.4 | 4.8 | | | |
| 9 | 1.7 | 50 | 1000 | CHO | 1.9 | 3.8 | — | — | 1.9 | — |
| 10A | 1.0 | 40 | 1000 | Both | 1.6 | 2.9 | 2.1 | — | — | 1.0 |
| B | 2.0 | 29 | 1000 | Both | 2.7 | 6.2 | — | — | — | 3.5 |
| 11 | 1.1 | 37 | 1000 | Both | 2.1 | 2.2 | — | — | — | 0.1 |

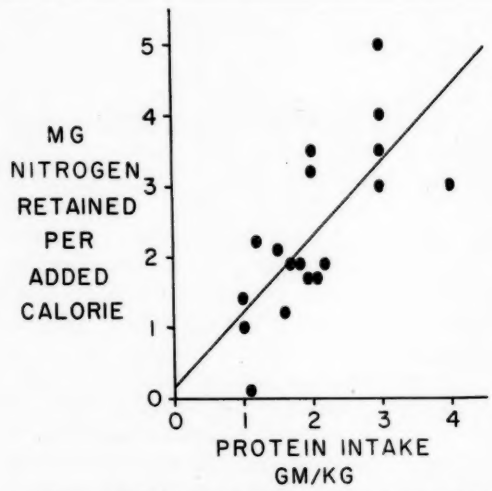


Fig. 4. Milligrams of nitrogen spared per added calorie as a function of dietary protein intake in grams per kilogram of body weight.

tissue which contains approximately 5 per cent nitrogen.

A series of calculations were performed to seek collateral evidence of the type of body tissue, fat or lean, formed in response to surfeit feeding. The ratios of nitrogen spared to weight gained were determined in each of the studies in Table I, but these ratios were highly variable, and so shed no light on the problem. In patients 2 and 3, the availability of balance figures for both nitrogen and sodium permitted the calculation of the theoretical weight changes from nitrogen (lean tissue) and from sodium (extracellular fluid). The theoretical weight changes from nitrogen and from both nitrogen and sodium are compared with observed weight changes in Figure 5. The difference between the observed weight change and the theoretical weight based on both nitrogen and

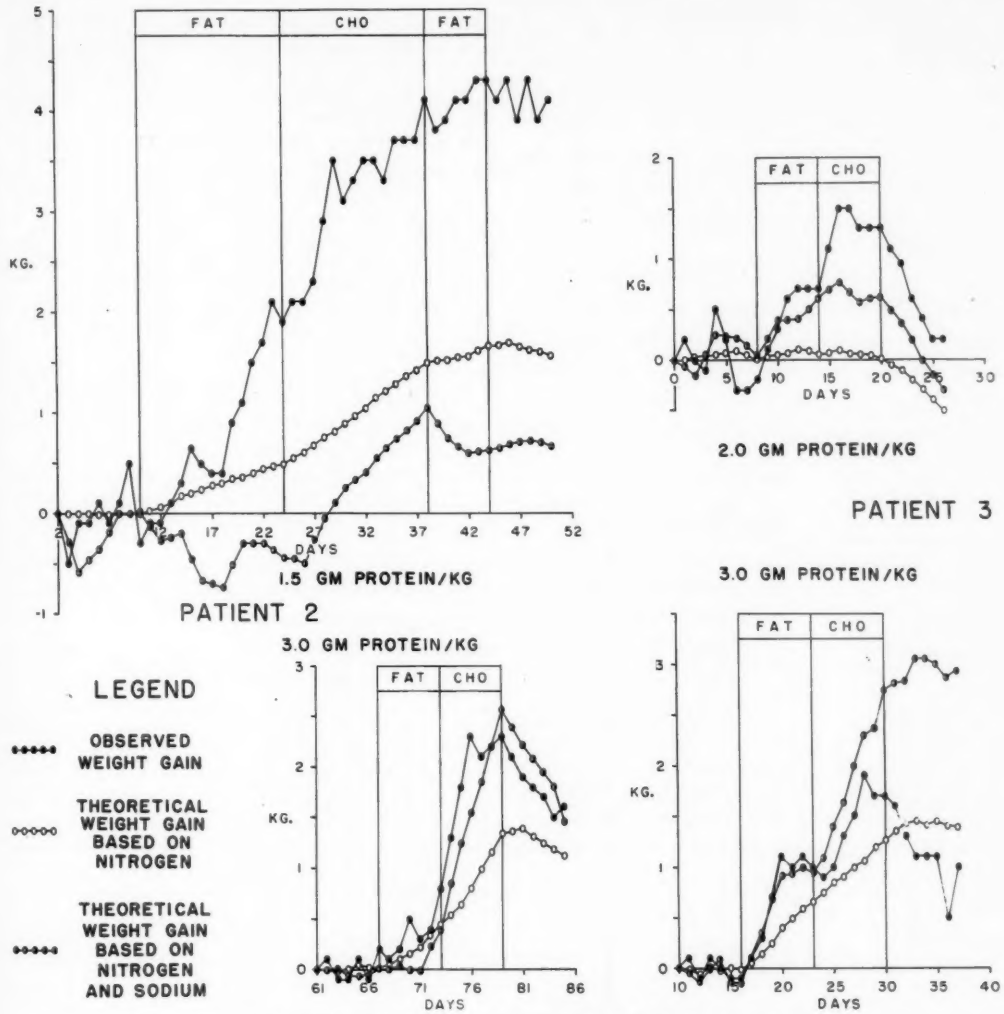


Fig. 5. Observed and theoretical weight changes during the studies in patients 2 and 3.

sodium may be considered to represent the change in body fat.

Examination of Figure 5 suggests that at the higher protein intake the weight gain is accounted for by gains in lean tissue and extracellular fluid, without increase in body fat; in fact, patient 3 may have lost fat in the after-control period. On the lower protein intake, patient 2 would seem to have gained mainly fat, patient 3 both lean tissue and fat.

In patient 2, attempts were made to follow changes in body fat both by measurement of skin-fold thickness and by densitometry. The former method indicated a gain of 1.5 kg of fat during the study on the lower protein diet, less than a third of the gain calculated from the balances. At the higher protein intake, the skin-fold measurements indicated a gain of 1 kg of fat, although the balance data suggested no change. Although densitometry, on the other hand, indicated a slight loss of body fat in both studies, these results should be discarded, since the small changes in specific gravity probably do not exceed the error of the method. The skin-fold thickness measurements, however, were consistent.

## SUMMARY AND CONCLUSIONS

In three patients with liver disease large supplements of carbohydrate or fat spared amounts of nitrogen varying from 1.4 to 6.5 milligrams per added calorie. In two patients the effects of carbohydrate and fat were equal; in the third patient carbohydrate was twice as effective as fat.

The amount of nitrogen spared per added calorie was directly related to the level of protein in the diet. It is suggested that at lower protein intakes an excess of calories leads to the formation of fat, but at higher protein levels leads to the formation of lean tissue.



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# The Prevalence and Incidence of Obesity in a Cross-Section of Elementary and Secondary School Children

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DATA ON the incidence and prevalence of obesity in children of school age are scarce. "Estimates" are encountered in published articles, but we could find no systematic study. The paucity of data may justify publication of the present report, in spite of its limited scope and certain questionable aspects of the method of sampling which had to be used. The results indicate that, with the criteria chosen here (based on the Wetzel Grid), more than 10 per cent of school children in the Boston area are obese.

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## METHODS

### *Selection of Sample*

Brookline and Newton were chosen as the sites of the study, because of interest expressed by the Health officers of these cities. The study was conducted during the school year 1952–1953. In Brookline, only the population of the public high school was studied. In Newton, a total of 9 out of the 28 public schools was studied. These schools appeared to be representative from the economic and ethnic standpoint of the public school population of the town as a whole, comprising well-to-do as well as poorer sections. The data from the records of 6,346 children, 2,658 boys and 3,688 girls, were included in the study. Table I gives a breakdown of the composition of the sample studied.

### *Criteria and Method of Study*

Height-weight data were obtained from school health records. The Wetzel Grid[1] was selected as a means of rapid evaluation of the "physical status" of a large number of children from height-weight records. The grid had been used briefly in several of the schools and the principals and school physicians were more or less familiar with it and were interested in seeing it used in their schools. Bruch recommended the Grid as a screening procedure for children with abnormal bodily dimensions.

Using the height and weight data from the most recent physical examinations in 1952–1953 recorded on the medical records, the Wetzel channel position for each student was

TABLE I

School Population and Sample Studied

| City | School division | Total no. | No. in study | Total enrollment no. | Total in study no. | Proportion in study |
|---|---|---|---|---|---|---|
| | | | | | | % |
| Brookline | Brookline High | 1 | 1 | 1,794 | 1764 | 98.1 |
| Newton | Total | 28 | 9 | 13,481 | 4593 | 34.0 |
| | Elementary | 23 | 6 | 8,232 | 1412 | 17.1 |
| | Junior High | 4 | 2 | 2,689 | 1140 | 42.3 |
| | Senior High | 1 | 1 | 2,560 | 2041 | 79.7 |

plotted on a recent version of the Wetzel Grid (copyright date, 1948). The grid was extended by additional equidistant parallel lines defining channels $A_5$, $A_6$, etc., beyond $A_4$. If a child did not have a record of a physical examination in 1952–1953 (in the spring of 1953 for elementary and junior high school students) his record was not included in this study. The physical examinations covered a period of from two weeks to three months in different schools. All age data were calculated on the basis of the examination being conducted in either October 1952 or April 1953. The age of each child at the last physical examination was counted to the nearest month from the birth date given in his record.

Wetzel's Grid limit for obesity, that is, "channel $A_4$ or above," was used as the criterion of obesity in this study. If a child were found to be channel $A_4$, $A_5$, $A_6$, etc., at his most recent physical examination in 1952–1953, his height-weight data were plotted on the grid back to the first grade or to the time at which his medical record in that school began.

## RESULTS

### *Wetzel Grid Classification of Total School Population*

Newton Schools: No significant or consistent differences were found between children in

TABLE II

Distribution of Students by Grade, in Three Parts of Wetzel Grid, Showing Proportions of Boys and of Girls in Middle Channel (M) and in Channels Above and Below Middle, 1952–1953

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| | | Wetzel grid channels | | | | Wetzel grid channels | | |
| Grade | Age and std. dev. (yr) | A $A_4^+$-$A_1$ | M | B $B_1$-$B_4^-$ | Age and std. dev. (yr) | A $A_4^+$-$A_1$ | M | B $B_1$-$B_4$ |
| | | | | *Newton Schools* | | | | |
| | | % | % | % | | % | % | % |
| I | 6.8 ± 0.4 | 47.8 | 27.1 | 25.0 | 6.6 ± 0.4 | 33.3 | 28.9 | 37.7 |
| II | 7.8 ± 0.5 | 46.6 | 25.6 | 27.9 | 7.8 ± 0.4 | 46.8 | 19.2 | 34.1 |
| III | 8.9 ± 0.5 | 35.8 | 22.0 | 42.2 | 8.8 ± 0.4 | 43.8 | 24.8 | 31.5 |
| IV | 9.9 ± 0.5 | 35.1 | 24.3 | 40.5 | 9.7 ± 0.4 | 38.8 | 14.6 | 46.6 |
| V | 10.8 ± 0.6 | 37.0 | 23.6 | 39.4 | 10.7 ± 0.5 | 45.0 | 18.6 | 36.3 |
| VI | 11.8 ± 0.6 | 42.9 | 19.8 | 37.2 | 11.7 ± 0.5 | 48.3 | 18.5 | 33.0 |
| VII | 12.8 ± 0.6 | 44.6 | 14.9 | 40.6 | 12.7 ± 0.5 | 54.3 | 15.2 | 30.5 |
| VIII | 13.8 ± 0.6 | 38.8 | 19.1 | 42.1 | 13.7 ± 0.6 | 53.5 | 21.7 | 24.8 |
| IX | 14.6 ± 0.6 | 35.3 | 24.8 | 39.8 | 14.2 ± 0.5 | 58.2 | 18.7 | 23.0 |
| X | — | — | — | — | 15.2 ± 0.6 | 53.4 | 20.9 | 25.6 |
| XI | 16.4 ± 0.7 | 50.1 | 16.7 | 33.0 | 16.3 ± 0.6 | 61.9 | 15.7 | 22.2 |
| XII | — | — | — | — | 17.3 ± 0.6 | 61.1 | 17.4 | 21.4 |
| | | | | *Brookline School* | | | | |
| IX | 14.2 ± 0.7 | 39.3 | 17.5 | 43.1 | 14.1 ± 0.6 | 54.8 | 21.3 | 23.9 |
| X | 15.2 ± 0.7 | 50.2 | 18.6 | 31.2 | 15.0 ± 0.6 | 63.7 | 17.7 | 18.6 |
| XI | 16.2 ± 0.7 | 47.3 | 22.0 | 30.7 | 16.1 ± 0.6 | 56.9 | 26.4 | 16.7 |
| XII | 17.2 ± 0.7 | 47.4 | 18.8 | 33.8 | 17.1 ± 0.6 | 69.3 | 13.9 | 16.8 |

TABLE III

Severity of Obesity by Wetzel Grid Channels Found in Boys and in Girls, by Grade

| | Boys Wetzel grid channels | | | | | | | | | | Girls Wetzel grid channels | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | | $A_4$-$A_5$ | | $A_6$-$A_7$ | | $A_8$-$A_9$ | | $A_{10}$ and over | | Total | | $A_4$-$A_5$ | | $A_6$-$A_7$ | | $A_8$-$A_9$ | | $A_{10}$ and over | |
| Grade | No. | % | No. | % | % | No. | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| I–V | 49 | 100 | 32 | 65 | 14 | 29 | 3 | 6 | — | — | 58 | 100 | 38 | 66 | 12 | 21 | 7 | 12 | 2 | 1.7 |
| VI–VIII | 54 | 100 | 36 | 67 | 12 | 22 | 6 | 11 | — | — | 78 | 100 | 50 | 64 | 21 | 27 | 6 | 8 | 1 | 1 |
| IX–XII | 131 | 100 | 84 | 64 | 35 | 27 | 10 | 8 | 1.5 | 1 | 333 | 100 | 222 | 67 | 71 | 21 | 32 | 10 | 7 | 2 |

the same grade but in different schools; therefore, the same grades were pooled for all elementary schools and for both junior high schools.

If the grid positions of the children in each grade are divided into three groups (those in channel $A_1$ or above, channel M, and channel $B_1$ and below), there is unequal distribution in the groups and considerable variation in the size of each group from grade to grade (Table II). The distribution is skewed toward the stockier side, especially in higher grades and particularly for girls, over 60 per cent of whom were in the "$A_1$ or over" category during the last two years of high school. More than 55 per cent of the girls were in this class in all the last four years of school. At no time except in grade 1 was the proportion of boys in the "$A_1$ or over" class as high as that of the girls in the same grade.

Brookline High School: Where data were available for comparison, the proportion of children falling in physique channels "$A_1$ or over" was similar for Brookline and Newton (Table II). Neither is consistently higher than the other for boys or for girls. Each school showed a higher proportion of girls than boys in the "$A_1$ or over" group. There were greater differences in the proportions in the "$A_1$ or over" group in boys and girls of the same grade and same school than between boys or girls of the same grades but different schools.

*Prevalence of Obesity*

According to the Wetzel Grid classification, in Newton a higher proportion of "obesity" (channel $A_4$ or over) was found among girls than among boys of the same grade except in grade 7, where 10.5 per cent of the girls and 11.5 per cent of the boys were obese. The prevalence rates by class and mean chronological age are shown in Tables III and IV.

No statistically significant difference could be demonstrated in obesity prevalence rates for boys or for girls between grades or between any physiologic age divisions when the data from all Newton schools were combined. The mean prevalence rate for girls in all 12 grades was 12.0 per cent. The mean obesity prevalence rate for boys in all grades was 8.65 per cent.

A statistically significant difference between grades was found in obesity prevalence rates for girls only in the Brookline High School. The rates observed varied widely from grade to grade, from 13 per cent in the 9th grade, 15 per cent in the 10th, 9 per cent in the 11th, and 19 per cent in the 12th grade. The rate of 19 per cent for the senior girls was the highest found at any time for girls or boys. The mean prevalence rate for Brookline High School girls was 14.5 per cent.

Except for the 11th grade, when the rates were almost identical, the obesity prevalence rate was consistently higher for girls than for boys. The mean prevalence rate for these boys was 9.9 per cent.

When the data from the Newton and Brookline schools were combined, an overall prevalence rate of 9.0 ± 2.5 per cent for boys and 12.5 ± 2.5 per cent for girls was found. (The measure of dispersion given is the standard error.)

*Severity of Obesity*

In both boys and girls, approximately two-thirds of all the obese students were in the

TABLE IV

Incidence of Obesity in Brookline Public High School and Selected Newton Public Schools, Showing for the Obese Individuals in Each Grade in 1952–1953 the Number and Proportion Who Were Also Known to Be Obese in 1951–1952

| | | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Percentage previously obese | | | | Percentage previously obese | |
| City | Grade | Total $A_4$ or over, 1952–1953 | Total $A_4$ or over, 1951–1952 | Positive % | No record* % | Total $A_4$ or over, 1952–1953 | Total $A_4$ or over, 1951–1952 | Positive % | No record* % |
| Brookline | IX | 19 | 16 | 84 | 10 | 30 | 20 | 67 | 17 |
| | X | 23 | 15 | 65 | 0 | 35 | 27 | 77 | 3 |
| | XI | 18 | 13 | 72 | 11 | 20 | 14 | 70 | 5 |
| | XII | 25 | 18 | 72 | 12 | 43 | 33 | 77 | 5 |
| Newton | II | 9 | 6 | 67 | 11 | 9 | 5 | 56 | 0 |
| | III | 9 | 3 | 33 | 11 | 6 | 1 | 17 | 33 |
| | IV | 7 | 2 | 29 | 29 | 16 | 13 | 81 | 12 |
| | V | 14 | 7 | 50 | 21 | 13 | 4 | 30 | 30 |
| | VI | 19 | 9 | 47 | 10 | 34 | 20 | 59 | 14 |
| | VII | 21 | 9 | 43 | 14 | 21 | 11 | 52 | 20 |
| | VIII | 12 | 9 | 75 | 16 | 22 | 16 | 72 | 4 |
| | IX | 18 | 14 | 78 | 11 | 60 | 34 | 58 | 23 |
| | X | — | — | — | — | 55 | 34 | 62 | 24 |
| | XI | 20 | 4 | 20 | 65 | 47 | 36 | 77 | 2 |
| | XII | — | — | — | — | 39 | 29 | 74 | 8 |

* Record not available for 1951–1952.

least severe channels ($A_4$–$A_5$ classification) (Table III). One-fifth to slightly under one-third of the students were in the next classification of obesity, channels $A_6$–$A_7$. Table III reveals that the girls had a wider range of severity of obesity than boys, but the two sexes were not strikingly different in proportions found in the different classes of severity of obesity.

*Obesity in the Preceding Year*

When the height-weight record of the preceding year was plotted on the grid for those who were found to be $A_4$ or over in 1952–1953, the students of the high school were more stable in maintaining their physique rating than those of the junior high school (Table IV). About 60 to 80 per cent of boys of Brookline and girls of Brookline and Newton in grades 9–12 who were obese in 1952–1953 had also been in this class the year before. In the grades 6–8 the proportion of students found to be obese the past two school years was lower, especially in grades 6 and 7. The numbers of children who were found to be obese in the elementary grades 1–5 were too small to be meaningful.

*Natural History of Obesity in the Individual Child*

The "obesity" history of the children found to be in channel $A_4$ or over in 1952–1953 was followed by grade throughout the school record. Records with more than two consecutive years missing were not included in this phase of the study.

In attempting to trace the obesity history of these children back to the first grade, three main characteristic patterns appear:

1. Persistent obesity: obese throughout the school record (from grade 1, 2, or 3) with not more than a total of two years in channels $A_3$–$A_4$ and the majority of grid positions $A_5$ or above. Out of 181 obese girls in grades 3–12 (Brookline and Newton) 33.7 per cent were in this group. Out of 68 boys in the same grade, 47 per cent were in group 1.

2. "Late" obesity: obese from grade 9 or 10 throughout or from grade 7 or 8 throughout or obese all last half of record. This group comprised 12.7 per cent of the girls and 38 per cent of the boys.

3. "Normal" year-to-year variation of "stocky" individuals never above $A_4$ or $A_5$, $A_5$, more than a total of one–two years (if two

TABLE V

Seasonal Onset of Obesity in Children, Grades I through IX, Showing Proportion of Individuals Who Were Found to be Obese at the Spring Examination But Not at the Previous Fall Examination

| Grade | Boys | | Girls | |
|---|---|---|---|---|
| | Known obese No. | Onset at spring exam % | Known obese No. | Onset at spring exam % |
| Total | 85 | 79 | 126 | 67 |
| I | 7 | 86 | 4 | 100 |
| II | 7 | 57 | 5 | 60 |
| III | 6 | 83 | 8 | 75 |
| IV | 7 | 71 | 11 | 54 |
| V | 9 | 89 | 8 | 100 |
| VI | 12 | 83 | 23 | 70 |
| VII | 17 | 94 | 13 | 54 |
| VIII | 6 | 50 | 13 | 62 |
| IX | 14 | 71 | 41 | 66 |

years $A_5$, not consecutive); never crossed more than one channel upward in one year. This pattern represented 21 per cent of the girls and 3 per cent of the boys.

Other patterns seen with considerably less frequency were:

(a) "early" obesity: obese first four, five, six, or seven grades; (b) obese at beginning and end of record, not during middle years; (c) obese middle and 12th years only; (d) "episodic" obesity: more than one "episode" of obesity (one to four years above $A_4$, preceded and followed by one to four years $A_3$ or below).

*Effect of Season on Onset of Obesity*

The children in kindergarten through grade 9 were weighed and measured twice a year. Consequently, the difference between occurrence of "obesity" at the fall examination and the spring examination could be studied in these grades.

A clear difference in seasonal onset of obesity may be observed in Table V. For those for whom the latest onset of obesity could be followed, the tendency to gain excess weight in comparison to height in the late fall, winter, and early spring is evident: 79 per cent of the boys and 67 per cent of the girls were obese at the spring examination, as compared with 21 and 32 per cent, respectively, at the fall examination.

## DISCUSSION

*Discussion of Methods: Criteria and Sampling*

The health records used in this study admitted of some serious limitations for the purposes of this study:

1. No record of maturational data.
2. No standardized procedure for physicians' evaluation of child's nutritional status, or continuous evaluation of year-to-year progress.
3. No information concerning pre-school and post-graduate status.
4. No opportunity for observation of the individual child.*

In addition to these limitations, there were obvious sources of error in the records: no checks on heights and weights, weight taken with non-standardized clothing at various times of the day, and not frequently enough over the space of a year.

The criteria used, based as they were on the Wetzel Grid, also admit of certain limitations. In the populations studied, the Wetzel Grid "physique channels" A (above middle, good-obese), M (medium or middle, good) and B (below middle, good-poor), did not divide the children into three equal groups (Table II). The distribution which was skewed toward the "A" side indicated that more of these children

* In one case, for one year only, "posture pictures" attached to the record and of girls only, helped to overcome this deficiency.

tended to be of the stocky than of the slender type. It would be helpful in interpretation of results and of interest to know if the findings at Brookline and Newton are characteristic only of this particular area and cultural group, or if it is a more general characteristic of growth and development not compensated for by the grid. If this is generally true, the Wetzel Grid would classify a higher proportion of children after 12 years of age as "stocky or obese" than would be expected if in-channel progress were characteristic. The skewed distribution toward the A side is more marked in girls than in boys and the tendency becomes progressively greater with advancing grades. This observation will be discussed in relation to comparison of prevalence of obesity in boys and girls. (Incidentally, contrary to the popular opinion that individuals of Jewish background tend to be heavy, the school with the predominantly Jewish population in this study did not show a greater tendency for the children to be in the "A" channels than the other school with a lower Jewish population. Ellis and Tallerman[2] also found no significant difference between Jewish and non-Jewish children in prevalence of obesity.)

Economic background in this sample also produced no significant differences in the proportions of children appearing in A or B physique channels as was shown by a comparison of children in the elementary schools of Newton. However, each school represented a group of mixed economic status, and although some of the populations were predominantly from the higher or lower economic groups, there was no clear-cut division by wealth.

*Discussion of Results: Prevalence of Obesity*

In the Newton Schools as in the Brookline High School, the prevalence of obesity was higher for girls than for boys in every grade with few exceptions (Tables III and IV). Although no significant difference between grades was demonstrated in obesity prevalence rates, the observed rates for girls were lowest in the first and second grades and highest in grades 4, 6, and 9. This might indicate that as a group these girls were tending to observe the expected pattern outlined by Stuart and Stevenson[3] of slow growth in the early school years with a pre-pubescent and pubescent tendency to gain weight with an increased weight:height ratio from ages 10 to 15 and a gradual deceleration of weight gain following.

The boys showed a tendency for increasing weight:height ratio in later grades than the girls, with the highest rates being found in grades 5–7 or ages 11–13 years. This is also in accord with the characteristic pattern of growth in boys. In both boys and girls the obesity prevalence rates were highest at the periods of greatest growth and immediately thereafter.

The mean obesity prevalence rates (12.5 per cent for girls and 9.0 per cent for boys) cannot be readily compared with data obtained with the use of other criteria. The figures obtained in this study include all degrees of obesity from the very mild or stocky individual to the extreme which would be classified as "$A_{12}A$" if the grid were continuous. It is thus not surprising that the values exceed the estimates of Shapiro[4] and Taylor and Schaefer[5] who studied only "mild obesity" and found about 3 per cent of their population to be obese. No comment is given concerning other forms of obesity in their groups. The mean rates of 9.0 and 12.5 of this study are two to three times the 3.82 which Salvioli[6] reported. However, he has not stated his method of evaluation or the age distribution of the children he studied. Apparently his group was younger, since he stressed the rates observed in the 3-, 8- and 11-year-old child only.

The mean values observed in the present study agree fairly closely with the prevalence rate of 9 per cent reported by Gray,[7] Talbot's[8] clinic population rate of "about 10 per cent" and the Life Extension Examination's[9] estimate of obesity in childhood of "10 per cent or more," each of which probably used a different norm for evaluation of obesity.

Wetzel's estimates of obesity, 2 per cent in boys and 7 per cent in girls, were considerably lower than those of the present study.

As in any other study, the "prevalence rate of obesity" was predetermined in part by the

standard or criterion used for judging obesity. It is recognized that the children called "obese" by this study were not differentiated according to excessive proportions of subcutaneous fat, muscle tissue, or bone. For example, among the boys classified as "obese" were football players, some of whom may have carried an unusual amount of fatty tissue, but most of whom undoubtedly had great muscular development, and one "weight-lifter" who was also probably unusually muscular. Limitations of the weight:height ratio have been discussed previously.[10]

The consistently higher prevalence rates of obesity among the girls may represent a significantly greater tendency of females toward obesity than males. However, unlike most other norms or standards, the Wetzel Grid uses the same basis of evaluation for boys and girls. It is a well-known fact that girls have more subcutaneous fat than boys at all ages with the difference becoming especially marked during adolescence. In the present study, the prevalence rate for obesity in girls tended to increase in adolescence, although no statistical difference between grades or chronological ages could be demonstrated. This could mean that the growth spurt in weight normally associated with adolescence could have been exaggerated and of greater duration than usual in these girls. On the other hand, there is a possibility that, as Garn[11] suggests, the grid does not allow for certain aspects of growth and development in girls, or as Stuart[3] suggests, the grid may fail to distinguish normal sex height-weight differences. The high obesity prevalence rate for girls in the high school and the large difference in prevalence rates for boys and for girls may thus be a reflection of an arbitrary definition rather than a measure of true obesity. Gray[7] and Bruch[12] each found the prevalence of obesity to be about the same in the two sexes. This, incidentally, would have been the result found here if the criteria had been "$A_3$ and above" for boys and "$A_4$ and above" for girls. Alternately, the data obtained here would appear to warrant considering shift in the numbering of the channels to differentiate between boys and girls.

*Duration of Obesity*

Of the children found to be obese in 1952–1953, considerably more of the high school students had also been obese the year before than of the junior high school group. This would seem to indicate that obesity is more likely to develop in the years between entrance into and graduation from junior high school (11–14 years) than in the high school years.

*Natural History of Obesity*

For the children of the high schools (Brookline and Newton combined) and junior high schools whose medical records could be followed from grade 1, three patterns for the course of obesity were most usual:

(a) Persistent obesity throughout the course of their school years was found in one-third of the girls and almost one-half of the boys. This was the most common obesity pattern for boys. It was probably associated either with a constitutional factor manifested early, or with early set habits associated with familial food or activity practices. Since it was initiated before the prepubescent or pubescent growth spurt, it is less likely that it was associated with endocrine factors such as the gonadal hormones which come into prominence during these latter phases of development. It is highly probable, too, that this group was weighted with stocky children, who, while "overweight" may not have been "overfat" and maintained themselves near the $A_4$ channel throughout growth.

(b) Late obesity or obesity occurring not earlier than grades 6–8 accounted for about one-third of the girls and a little over one-third of the boys. This marks the period of entrance into junior high school and the beginning or acceleration of maturational changes, endocrine in particular.

The children who were obese only the last one or two years of their school days would likely include children in the decelerating phase of adolescent growth, a period often characterized by muscle growth in boys and a tendency to continue the addition of subcutaneous fat as the height increment decreases in both boys and girls.

(c) Normal year-to-year variation of

"stocky" individuals. This classification applied to about one-fifth of the girls and to only about one-tenth of the boys in the high school group. In the junior high school group this classification assumed greater importance, taking in over one-third of both boys and girls.

It must be noted, however, that since only those students found to be in channel $A_4$ or above in 1952–1953 were followed, it is obvious that children who were obese either in the early or middle years or both, but not in the later years, would not have been included in this sample.

Finally, the tendency for children to gain excess weight in proportion to height in the autumn and winter as compared with spring and summer is demonstrated in the present sample. The great majority of obese children in all grades (200 girls and 70 boys followed) accumulated their excess weight during the fall and winter period. Since most of these children were from a better-than-average economic background, it is not likely that the nutritional status of so high a proportion would have been poor enough in any 6-month period to lead to "less-than-optimum growth rates" as suggested by Bransby[13] in his study. This marked tendency which was observed in all age groups from grades 1 through 9 and with both boys and girls is much more likely to have been due to changes in physical activities. A study of the energetics of obesity in children demonstrating the importance of lack of physical activity in the caloric imbalance of obese girls selected from the population group described here has already been reported.[14]

## SUMMARY

A study of the incidence and prevalence of overweight among school children in two communities within the greater Boston area was conducted, using school records as source of information and the Wetzel Grid as basis for definition of overweight. The data demonstrated that, with the criteria used, more than 10 per cent of the children in this area are "overweight." From the point of view of development, two types were found to be most common: "persistent obesity," present throughout the school record, which comprised a third of the overweight girls and almost half of the overweight boys; "late obesity," present during the latter half of the record, which comprised 12 per cent of the overweight girls and over a third of the overweight boys. By and large, onset of overweight took place during the winter months, which may be taken as emphasizing the importance of inactivity in the etiology of many cases of obesity.

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# Dietary Intake and Social Characteristics

*By* JEAN K. BOEK, PH.D.*

THE CONTENT of people's diets, as well as factors associated with food choice, are of interest to nutritionists and social scientists alike. The studies conducted by both groups of scientists in different parts of the world have contributed evidence that food intake of an individual is influenced by the rules and traditions of the society in which he lives and by his relative position within that society. A number of the surveys have shown quite specifically how variations in diet are associated with differences in the social environment. Such studies involve description and measurement not only of diet but also of factors in the social milieu. Results of these investigations were utilized in the present research in the formulation of hypotheses which were tested in a study of 184 Michigan farmers.

## RESEARCH METHODS

The 184 farm operators lived in or near Hillsdale County, which is in the southernmost tier of Michigan counties. Criteria for their selection were that they were male heads of households which had never been broken through death or separation, that they were actively operating a farm, and that they had either at one time received a Farmers Home Administration loan or were similar to a family which had received an FHA loan. The selection process thus resulted in a group homogeneous with respect to family status, occupation, sex, locale, and age in that all were in the productive years of their lives.

They were interviewed with a schedule of questions in their homes during the summer of 1950, which meant seasonal factors influencing diet were kept constant. Dietary information was obtained using the 24-hour recall technique. This had the advantages of securing the co-operation of every respondent and of permitting everyone to remember his intake easily and accurately. The 24-hour period was the entire day prior to that of the interview, a modification of the technique utilized by Ohlson and others.[1,2] An approximately equal number of diets were obtained for each day of the week.

Eight different social characteristics were chosen for comparison with food intake. Four of the characteristics were measured by utilization of scales, and the remaining were obtained by direct questioning. Scales were used for (1) participation in community organizations, (2) informal visiting, (3) level of living, and (4) health.

For *organizational participation*, the scale consisted of questions of membership, attendance, and committee or officer posts held in organized groups such as Farm Bureau, church, political parties, and others during the year prior to the interview. Financial contributions to associations and public offices occupied were also recorded. The sum of points given for each answer was the operational definition of organizational participation.

The scale for *informal participation* consisted of points for type and frequency of visiting with friends and relatives on occasions such as dinners, evening gatherings, auctions, or sports.

The *level of living* scale was composed of questions about possession of household goods and conveniences.

*Health* was operationally defined as number of symptoms a man said he had during the six months prior to the interview. The Symptoms Schedule used had been developed and validated by a team of social scientists and

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physicians. It was made up of items such as unexplained tiredness, persistent headache, repeated vomiting, and other symptoms considered to be indicative of present or potentially serious ailments.[3]

*Income, years of schooling, size of household,* and *age* were ascertained by direct inquiry. Income was gross amount earned by the family during 1949, and many respondents answered the question by showing the interviewer their income tax return for that year. Years of schooling was amount of formal training received, and size of household was the number of persons who ate together, a definition similar to the one used by Eppright (Ref. 4, p. 909).

In analysis of interview data, diet records were translated into number of calories, milligrams of ascorbic acid, and grams of calcium, using a Department of Agriculture table.[5] The number of different foods were counted to indicate the variety of the menu. These data, along with measurements of the eight characteristics of the men, were punched on Holerith cards and tabulated by machine.

Comparisons of the four dietary measures with each of the eight characteristics were made initially in 32 marginal tables. The 32 comparisons were tested for association by coefficient of correlation using procedures for grouped data as a general guide (Ref. 6, pp. 673–678). Significance of $r$ was determined with the use of Edward's Table D (Ref. 7, p. 331). Where other survey material pointed to the possibility that association between dietary and other factors might be curvilinear rather than linear, a second test was made with correlation ratio, adapted from methods presented in Croxton and Cowden (Ref. 6, pp. 721–727). The test of significance used for $\eta$ was epsilon-square, according to the formula:

$$\epsilon^2_{yx} = \frac{\eta^2_{yx}(N-1)-(k-1)}{N-k}$$

and Table F in Edwards (Ref. 7, pp. 232; 339).

## DISCUSSION OF FINDINGS

The major hypothesis of the study was that an association exists between diet and the eight characteristics measured. For each of the dietary measures and the sociological characteristics, working hypotheses were formulated and tested. Discussion of these findings are arranged by the eight factors and all results are summarized in Table I, which also includes mean dietary values for the men.

### *Diet and Organizational Participation*

Men who are active in the formal organizational life of a community have different experiences than those who are not, and these differences may extend to their attitude and behavior concerning food. The men more active in community associations were found to have diets containing greater amounts of calcium and a greater variety of foods than those who participated less.

### *Diet and Informal Participation*

In a setting where people are together for relaxation rather than working for some formal goal, there can be a free exchange of news, ideas, and information, and there can be a re-enforcement or alteration of individual values. It is a situation in which patterns of food intake can be influenced both through discussion and through what is served during the visits. In their study of southern rural regions, Cussler and DeGive[8] found family dinners and informal visiting to be important in dissemination of ideas about content and preparation of meals, as well as in sharing out-of-the-ordinary foods. The leading role played by a neighbor or relative in suggesting new methods of preparation, and experiences with different foods through visiting in a rural area was pointed out by Dickens.[9] For the 184 Michigan farmers, however, there was no linear relationship between amount of visiting done and diet, as indicated by the low $r$'s in Table I.

### *Diet and Level of Living*

In this investigation, the level of living score was regarded as a mirror of ability to possess goods and services valued by members of this society. In a real sense, it is the interpretation of income in terms of values and aspirations of a family which is related to their position within the society. Measures of social position, somewhat analogous to the concept of level of living, were utilized in a United States and a French study. In both instances diets were found to vary in quality and quantity at different levels of the social structure.[10,11]

TABLE I

Summary of Statistical Tests of Relationship of Four Dietary Measures and Eight Sociological Characteristics, as well as Group Dietary Means, for 184 Michigan Farmers

| Sociological characteristic and statistical test used | Results with respect to dietary measures | | | |
|---|---|---|---|---|
| | Calories | Ascorbic acid | Calcium | Number of foods |
| | | *mg.* | *g.* | |
| Organizational participation | | | | |
| Correlation coefficient | +0.093 | +0.113 | +0.195* | +0.161* |
| Informal participation | | | | |
| Correlation coefficient | +0.002 | +0.005 | +0.021 | +0.089 |
| Level of living | | | | |
| Correlation coefficient | +0.056 | +0.064 | +0.087 | +0.021 |
| Correlation ratio | 0.95* | 0.89* | | |
| Income | | | | |
| Correlation coefficient | +0.002 | +0.127 | +0.117 | +0.078 |
| Correlation ratio | 0.31** | 0.25 | 0.32** | |
| Schooling | | | | |
| Correlation coefficient | −0.016 | +0.090 | +0.221* | +0.124 |
| Correlation ratio | 0.13 | | | |
| Household size | | | | |
| Correlation coefficient | +0.057 | −0.094 | +0.095 | −0.144 |
| Correlation ratio | | 0.26 | 0.45* | 0.54* |
| Age | | | | |
| Correlation coefficient | −0.227* | −0.001 | −0.196* | −0.063 |
| Health (number of symptoms) | | | | |
| Correlation coefficient | −0.114 | +0.002 | −0.219* | −0.016 |
| Means for the 184 men | 3,510 | 139 | 1.33 | 17.6 |

* Significant at 1% level.
** Significant at 5% level.

At different levels of living for the Michigan group, diet was found to vary with respect to calories and ascorbic acid content, as shown by the highly significant correlation ratios. Level of living and grams of calcium and level of living and number of foods, however, were not found to be related.

*Diet and Income*

The most common comparison in American and European dietary surveys has been of food intake with income. The frequency of this comparison is not unexpected, since money is an important gauge of many characteristics of Western society. A few findings from the surveys most nearly pertinent to the present investigation can be cited.

The diets of United States farm families, sampled April to June 1942, were shown to have increased energy value and then to diminish in calories as income went up.[12] Eighty-one Tennessee farm families who spent more for food had a greater caloric intake than those spending less.[13] Rising income of Georgia and Ohio farm families was associated with a greater energy value of their diets.[14]

For the 184 men reported in this study, the relationship between income and calories paralleled that of the sample of United States farm families in being curvilinear.

Among the surveys showing a change in vitamin C intake at different income levels was one carried out on a nation-wide sample by Gallup and his staff,[15] who reported that the proportion of diets lacking vitamin C was highest in the low income class and lowest in the top income group. Georgia farm families were able to have a greater ascorbic acid intake with rising income, but for the Ohio farm group, ascorbic acid content went from 115 mg to 100 mg, 106 mg, 130 mg, and 140 mg as annual income rose from under $494 to over $2995.[14] A somewhat different result was reported in the 1942 United States study where average daily intake for farm dwellers was 110 mg, 120 mg, 155 mg, 145 mg, and 124 mg as income increased.[12] More money was spent for food

by Groton Township, New York, farm families than others in the survey, and they had a higher nutrient usage which included vitamin C (Ref. 16, p. 670).

No relationship between income and ascorbic acid intake was found for the Michigan farm operators, as indicated by the low $r$'s and $\eta$'s in Table I. This may be the consequence of summer availability of fresh fruits and vegetables to all the men irrespective of income.

Because milk and milk products are the most important sources of calcium in American diets, survey data concerning grams of calcium as well as amount of milk present in menus were useful as background for the present study. Comparisons of amount of this mineral in the food intake of Georgia and Ohio farm families showed slight increases in calcium with rising income.[14] Rising income of United States farm families was found to be associated with a calcium intake of 1.2 g, 1.3. g, and 1.4 g.[12] With increasing income among an Iowa group, no consistent tendency was found for a greater proportion of diets to be satisfactory in milk (Ref. 4, p. 886). The middle and upper income levels in Gallup's study were similar in consumption of milk and cheese, and a smaller percentage of their diets lacked these foods than occurred in the lowest income class.[15] Results similar to the Georgia and Ohio study were found with respect to milk available for drinking among Tennessee families, where those spending more for food than others used more milk.[13]

The relationship between income and calcium intake for the Michigan farmers was significant and nonlinear.

The number of different foods present in a food record has not often been used as a measure of diet. In one of two studies in which this was considered, it was observed that amount and quality of family food depended on income, with those having a greater income able to have more kinds and a greater quantity of food.[17] Lewis found the correlation between diet and wealth to be a positive one in the village of Tepoztlan, in that all wealthier families had larger meals with a greater variety of foods throughout the year than was noted in other families (Ref. 18, p. 189).

Although it was expected that among the 184 men having higher incomes the number of foods would be greater, no significant existence of linear relationship was found.

*Diet and Schooling*

As with the comparisons of life-situation factors and diets just discussed, there was no plethora of similar studies to draw upon as a basis for hypothesis formulation and discussion concerning relationship of schooling and food intake. In three surveys in which education was considered in relation to diet, the results were suggestive, but not similar to each other. Education and the degree of acculturation were reported as beginning to create real differences in the diet of the Tepoztlan population in terms of eating new and out-of-season foods (Ref. 18, p. 9). Use of multiple correlation in her study showed Mack that one-half of the variation in dietary choice by families was determined by a combination of education and food expenditures, with family education having twice as much influence as the other in food selection.[19] In Groton Township, however, no apparent relationship was found between average nutrient availability and formal education of either husband or wife (Ref. 16, p. 873).

The only significant relationship between diet and schooling for the Michigan farm operators was that as the number of years of schooling rose, the calcium intake of the men increased.

*Diet and Size of Household*

The basic assumption in comparing household size to the diet of the father is that the content of his meal may be affected by how many there are for whom food must be purchased and prepared. A wife cooking for two may not use the same type of foods and methods of preparation that cooking for three or more might require, especially if the additional household members are children. In addition to exerting a possible influence on meal preparation, household size is associated with position in the social structure. Although not stated in this fashion, the findings in a number of diet studies of changing food intake with different family size reflect, in part

at least, what would happen to an American primary family as it had less and less to spend for food.[14,20,21] In other words, it may not be family size *per se* which is of significance, but rather the association of family size with other factors in the social milieu which are important in determining the food reaching the table.

Findings from the present study indicated that the relationship of diet and household size was not a linear one, although the $r$ of minus 0.144 for household size and number of foods approached the five per cent level of significance. Instead, two highly significant $\eta$'s showed that differences in household size were related in a curvilinear fashion to changes in calcium intake, as well as to number of foods in the diet of the head of the household.

*Diet and Age*

Differences in diet according to age level have been reported in a number of investigations. In the Groton Township study, as the age of the men increased from 21 to 69 years, the caloric content of their diets tended to decrease, but in the 70 years and over age range, there was a slight increase. Ascorbic acid intake showed a decrease with age except in the 50–59 years category, in which there was a slight increase. The amount of calcium in the diet, highest in the 21–29 year class, became irregularly less in the succeeding age groups, the men 70 and over having an intake almost as high as the youngest group.[22] It has been reported that male aircraft workers under age 25 tended to eat more citrus fruit and to drink more milk than those who were older.[23] Iowans of age 17 to 19, and 46 to 58 ate similar amounts of citrus fruits and tomatoes, but the proportion of the younger age group having diets satisfactory with respect to milk was almost three times that of the older age group (Ref. 4, p. 886). In a study of women in Michigan, calcium intake was found to decrease in successive age decades.[24]

For the 184 men studied, the amounts of calories and calcium in their diets decreased as age increased, which parallels the results of investigations just cited. The lack of a significant relationship of age and intake of ascorbic acid is also similar to the other findings.

*Diet and Health*

Although health is usually defined in physiological terms, in a real sense it is tied in with a person's general way of life. The physical well-being of an individual is a cumulative result of many environmental factors such as occupation, values, and knowledge centered on health practices, social stress, availability of medical and dental care, and behavior concerning diet. In this study, with the factors of occupation and availability of health care more or less similar for all the men, the comparison of health to dietary practices is a meaningful one. It was found that farm operators having the "best health" (smallest number of symptoms) had the highest amounts of calcium in their meals. This result has to be interpreted in the light of the significant relationship of calcium and age. The younger men, who also might be expected to be healthier, had higher intakes of calcium than the others. The factors of age and relative health are probably not unrelated for this group. The data can also be compared with those from Iowa where no significant differences were found in the type of menus among people having many or few health complaints (Ref. 4, p. 959).

## SUMMARY AND CONCLUSIONS

In this study of 184 Michigan farmers, the 24-hour recall record of diet was translated into number of calories, milligrams of ascorbic acid, grams of calcium, and number of different foods, for comparison with each of eight measures of their social milieu. In 12 of the 32 comparisons, statistical support was given to the general hypothesis that an association exists between food intake and social environment.

It was found that men who participated more in organized community activities had higher intakes of calcium and a greater variety of foods in their meals than those who were less active. Significant linear relationships were also found for calcium and schooling, age, and health, which meant that the more schooling the men had, and the younger and more healthy they were, the greater was the amount of calcium in their diets. Younger men also had diets of higher energy value than the older men.

The tests indicated that as level of living and income for the group changed, this was accompanied by differences in the amount of calories in their food. The ascorbic acid content of diet also changed with different levels of living. Variations in income were associated with changes in caloric and calcium intake, and variations in household size with changes in calcium and number of foods appearing in the records.

The lack of any linear correlation between ascorbic acid and the eight social factors may reflect the availability of fresh foods high in vitamin C to all of these men in the summer months when they were interviewed. Such availability seemed to be true whether they were young or old, active in organizations or not, living in large or small households, and the like. It is possible that further significant correlations between dietary and social factors would exist in other groups of men and that they did not show up here because this group was relatively homogeneous.

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### *Human Ecology*

"... Unlike our ancestors who had to consider only one problem, we in the medical profession must now recognise that developments in the preventive and curative fields can no longer be worked out in isolation. They must be considered in the broad perspective of the economic and human resources of the area, country or continent; the physical resources, including power and water; the level of education of the people concerned; and, above all, the ability to feed the people and maintain a high standard of nutrition.

"In all of these subjects basic research is required, for we know relatively little about soil and soil fertility, and next to nothing about the long-term availability of natural resources. Indeed, we do not yet really know the true facts about the population of the world and its mortality and morbidity. We are also, as yet, grossly ignorant of the factors which make for human happiness and peace of mind, and it is in this field of mental health and well-being that the greatest contribution remains to be made.

"Human ecology is regarded by some people as a way of thinking or a philosophy of life, but I would prefer that it should also be a method of approach whereby a number of experts combine to work out problems which would otherwise remain unsolved. Many of the basic problems relating to disease in the individual have now been solved, and in their place have come the problems of the community."
—A. Leslie Banks. *Med. Press* 234: 229, 1955.

# High Fluoride Content of Teeth from Communities with Low Fluoride Water Supplies

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THE STRIKING difference between the incidence of caries in the people in the countries of Western Europe and North America and the incidence in the citizens of Far Eastern countries is readily evident from a comparison of surveys in the literature. In contrast to the United States, the caries incidence in India is particularly low, in spite of what appears to be a high consumption of carbohydrates.

The extent of freedom from tooth decay among children in India can be seen from the data from six surveys[1–6] that are presented in Table I. The per cent of children with no carious lesions in their deciduous teeth varied from 73.6 up to as high as 93.5. Even higher freedom from dental caries was observed among the permanent teeth of the same children, with as many as 89.6 to 97.1 per cent of the children being caries-free.

The contrast among American children is appalling. Results of four surveys[7,8] in New England are tabulated in Table II. Obviously, these data indicate that relatively few children in the 12- to 14-year-old age group have escaped the ravages of tooth decay. The most intensive survey tabulated is the one in which 4,146 children from 26 communities were studied. Of these, only 0.6 per cent had caries-free permanent teeth, and the average number of diseased teeth amounted to 11.1 per child.

These differences suggested the possible value of analytical evaluations of the teeth from representative groups of people in India and America. Because of the increasing body of data on the relationship of the fluoride ion to the development of teeth and their later resistance to tooth decay,[9] it was decided that the initial analytical approach to the problem would be a determination of the fluoride content of the enamel and dentin. Other analyses are to be conducted later to determine what quantitative variations exist between teeth from these populations.

## EXPERIMENTAL

A total of 161 teeth were collected from 52 patients in a clinic in Delhi, India. The individuals varied in age from 26 to 70 years. Another 75 teeth were made available from 36 patients in a hospital dental clinic in Bombay, India. These subjects ranged in age from 25 to 70 years. A total of 58 teeth were available from two sources in Boston from 35 patients, whose ages varied from 6 to 60 years. The place of residence during youth, the cause of tooth extraction, and the type of tooth were recorded. Detailed visual observations were made of the gross appearance and structure. Each tooth was carefully cleaned to remove all calculus, carious material and superficial surface stains. The crown was cut off from the root or roots by a power jigsaw. The crowns were pulverized in a diamond mortar until the particles were sufficiently small to pass through a 100-mesh sieve. The enamel and dentin were separated from each other by a flotation-

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centrifugation procedure, with a bromoform-acetone mixture as described by Manly and Hodge.[10] Distillation of the fluoride from contaminating materials for enamel, dentin, and tap water samples was conducted in polyethylene bottles by the procedure described by Singer and Armstrong.[11] Distillation of the fluoride from sea salt samples was conducted by the double distillation procedure of Churchill, Bridges, and Rowley.[12] The amount of fluoride in the distillate from either procedure was determined by a colorimetric method described by Icken and Blank.[13]

TABLE I

Dental Caries Incidence among Children in Various Areas of India

| Location | Type of group | No. of children | Age of children | Caries-free children | No. of deciduous teeth | Caries-free deciduous teeth | No. of permanent teeth | Caries-free permanent teeth |
|---|---|---|---|---|---|---|---|---|
| | | | *years* | % | | % | | % |
| North, South and Central India[1] | — | 6866 | 6–18 | 44.5 | 38,670 | 89.2 | 139,679 | 96.0 |
| Delhi Province[1] | Rural | 977 | 5–16 | 53.7 | 8,531 | 93.5 | 16,674 | 97.1 |
| | Urban | 1071 | 5–16 | 38.5 | 10,562 | 90.8 | 16,795 | 96.6 |
| Bombay[2] | A* | 1434 | 3–20 | 22.7 | 5,235 | 69.2 | 32,659 | 89.6 |
| | B† | 761 | 3–20 | 36.9 | 516 | 75.4 | 20,467 | 92.1 |
| Gujrat[3] | Boys | 581 | 3–15 | 31.6 | 5,984 | 79.7 | 7,739 | 92.6 |
| | Girls | 482 | 3–15 | 30.7 | 4,420 | 73.6 | 6,989 | 91.7 |
| Amritsar[4] | Boys | 200 | 8–13 | 41.5 | — | — | 4,986‡ | 91.0 |
| | Girls | 200 | 8–13 | 55.5 | — | — | 5,258‡ | 96.1 |
| Moga (Punjab)[5] | — | 727 | 6–20 | 40.9 | 3,530 | 82.0 | 16,933 | 91.4 |
| Lucknow[6] | — | 793 | 13–20 | 60.7 | — | — | 22,811‡ | 96.7 |

* Children came from upper middle class families.

† Children were inmates in institutions for juvenile correction.

‡ Total number of deciduous and permanent teeth.

TABLE II

Dental Caries Incidence in 12–14-Year-Old Children in Various Communities of New England

| Location | Type of group | No. of children examined | Children with caries-free permanent teeth | Average D.M.F.* |
|---|---|---|---|---|
| | | | % | |
| Lynn, Mass.[7] | Boys | 224 | 17.6 | 5.4 |
| | Girls | 205 | 24.9 | 5.2 |
| Worcester, Mass.[7] | Boys | 577 | 8.3 | 6.6 |
| | Girls | 562 | 9.1 | 7.5 |
| South Portland, Me.[7] | Boys | 357 | 7.3 | 9.3 |
| | Girls | 321 | 7.8 | 8.9 |
| 26 Massachusetts communities[8] | — | 4146 | 0.6 | 11.1 |

* D.M.F.—Decayed, missing, filled teeth.

## RESULTS

The 52 individuals from whom teeth were extracted in the Delhi clinic came from different areas of India. Twenty-eight were lifetime residents of Delhi city; 4 had resided in Delhi state, that is, within a distance of 10 to 12 miles from the city; and 20 had come from several other areas in India. The following types of teeth were represented among the 161 available: 42 incisors, 33 canines, 38 premolars, 45 molars, and 3 for which no record is available. There were 15 carious teeth involving 12 molars and 3 premolars. The total number of carious surfaces was 18. The 36 patients from whom teeth were available in Bombay were believed to have been residents of that city for the majority of their lives, although detailed data were not available to support this statement. The following numbers of teeth were represented in this sample: 11 incisors, 15 canines, 29 premolars, and 20 molars. Carious lesions were observed in 4 premolars

and 5 molars with only 10 surfaces involved in the carious processes. The Indian teeth were all permanent ones.

Two groups of Boston teeth were collected and analyzed with an appreciable time interval between the collection periods. The one group was composed of 30 permanent teeth collected from 17 lifetime Boston residents: 8 of these teeth were premolars, 2 were first molars, 4 were second molars, and 16 were impacted third molars. Ten of the 14 premolars and first and second molars had carious lesions. In the other group, there were 28 teeth from 18 Boston residents: 1 was an incisor, 5 were canines, 2 were premolars, and 20 were molars. Of these teeth, only 6 were caries-free: 1 incisor, 1 premolar, and 4 molars. Seven of the teeth from one individual were deciduous.

In addition to the obvious difference in caries incidence between the teeth of Indian residents and those of Boston, there were other striking and readily visible differences. The enamel of the Indian teeth collected in Delhi and Bombay had a very high surface gloss and translucency, whereas there was a certain dullness and opacity to the enamel of almost all the Boston teeth. A high percentage of the Indian teeth had a slight marbled effect strongly resembling the less severe degrees of chronic endemic dental fluorosis (mottled enamel) described by Dean.[14] In no case was the manifestation of mottled enamel considered to be more severe than the very mild and mild categories defined by Dean. In Boston teeth there was no evidence of mottling but there was a characteristically different type of chalky dull area that could be readily distinguished from the mottled areas observed in the Indian teeth.

TABLE III

Fluoride Content of Enamel and Dentin from Teeth of Residents in Delhi and Bombay, India, and in Boston, Mass.

| Residence at time of extraction | Residence during childhood | No. of cases | Fluoride content of childhood water supply | Fluoride content of enamel | | | Fluoride content of dentin | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average* | S.E.M.† | C.R.‡ | Average* | S.E.M.† | C.R.‡ | |
| | | | *p.p.m.* | *p.p.m.* | *p.p.m.* | | *p.p.m.* | *p.p.m.* | | |
| Boston | Boston | 17 | 0.12 | 40(25–89) | 7 | 1.7 | 85(50–190) | 18 | 0.9 | |
| Boston | Boston | 18 | 0.12 | 58(30–180) | 8 | 11.7 | 109(51–437) | 21 | 11.3 | |
| Delhi | Delhi | 28 | 0.25 | 299(156–576) | 19 | 1.0 | 710(286–1472) | 49 | 10.8 | |
| Delhi | Various areas of India | 24 | ? | 305(129–762) | 21 | 5.1 | 706(270–1563) | 51 | 4.3 | |
| Bombay | Bombay | 36 | 0.04 | 184(83–367) | 12 | 8.8 | 456(228–935) | 32 | 9.1 | |

* Average with range in parentheses.

† S.E.M.—Standard error of mean.

‡ C.R.—Critical ratio. The critical ratio is the ratio of the difference between two means to the standard error of the difference between the means. Wherever the critical ratio is less than 2.0, the difference between the means is considered to be statistically insignificant; when from 2.0 to 2.9, moderately significant; when 3.0 or higher, highly significant.

Many of the Indian teeth had large and highly pigmented areas of calculus, whereas the Boston teeth were largely free of such deposits. The majority of these stains were due to betel nut chewing. The crowns of numerous Indian teeth were completely covered by heavy incrustations of calculus that extended well beyond the cemento-enamel junction. There was a definite impression that the roots of the Indian teeth were much more resistant to cutting with the jigsaw than roots of comparable size among the Boston teeth.

The fluoride analyses of these four groups of teeth revealed striking differences in the enamel and dentin for the different population groups. These values are presented in Table III. The average fluoride concentration in the enamel of the teeth of the 28 individuals who were residents of Delhi was 299 p.p.m. The average enamel fluoride value for the 24 individuals who had not spent the majority of their lives in Delhi but for whom extractions were performed in Delhi was 305 p.p.m. The comparable value for the 36 individuals from whom teeth were extracted in Bombay was 184 p.p.m. These three values are in sharp contrast to the

average fluoride value of 40 p.p.m. for one group of 17 individuals in Boston and of 58 p.p.m. for another 18 people in Boston. The average fluoride content of the dentin of the teeth of the 28 Delhi residents was 710 p.p.m. while that of the 24 non-Delhi residents was 706 p.p.m. The fluoride value for the dentin from the teeth from Bombay was 456 p.p.m. The contrast between these values and the 85 and 109 p.p.m. for the dentin from Boston teeth is striking.

The differences between the fluoride levels in the enamel and dentin of individuals for whom extractions were performed in Bombay and Delhi and those in Boston were judged by statistical evaluation to be highly significant. Likewise, the fluoride values for enamel and dentin of teeth from Delhi residents were higher to a highly significant degree than comparable values for the teeth of Bombay residents. No significant difference was observed between the fluoride values of dental tissues from the 28 lifetime Delhi residents and the 24 individuals who had spent the majority of their life elsewhere in India.

Two samples of Delhi tap water were found to have fluoride concentrations of 0.2 and 0.3 p.p.m. The one sample of water from Bombay had a fluoride concentration of 0.04 p.p.m. Numerous samples of Boston water as available in this laboratory were found to contain an average of 0.12 p.p.m.

## DISCUSSION

Reports of mottled enamel associated with high fluoride water supplies have been presented for inhabitants in the Nellore district of South India[15,16] and for the Punjab in North India.[17] Unfortunately, no fluoride analyses were reported on the enamel and dentin of these teeth for correlation with the fluoride content of the water.

The data presented in this paper indicated the occurrence of mottled enamel and major levels of fluoride in the enamel and dentin of residents of other Indian communities where the water supplies contained low levels of fluorides. The striking contrast between the high fluoride levels in the enamel and dentin of teeth from Delhi and Bombay and the low levels in the enamel and dentin of Boston teeth is the more remarkable in view of the relatively comparable low fluoride levels of the communal water supplies in all three cities. The average values observed for the fluoride content of enamel and dentin from 18 Boston residents were somewhat lower than the general range of fluoride levels reported for the dental tissues of individuals whose teeth were developed in areas where the communal water supplies contained low amounts of fluorides.[18] In contrast, the average fluoride levels in the teeth of the 28 Delhi residents and the 24 individuals from various other parts of India for whom extractions were performed in Delhi were comparable to the fluoride levels of individuals in other parts of the world who were exposed to drinking waters containing 2.5 to 3.5 p.p.m. during periods of tooth calcification. Yet the Delhi water contained only 0.25 p.p.m. fluorides. The average fluoride values for enamel and dentin of teeth from 36 Bombay residents were approximately comparable to the levels reported for individuals when the water supply contained 1.2 to 1.9 p.p.m. However, Bombay water contained only 0.04 p.p.m. fluorides.

On the basis of our present knowledge of the climatic circumstances in India, it is likely that the high average annual temperatures in many areas would lead to appreciably higher water intakes by the residents in those communities than would obtain for individuals in the Boston area or other temperate areas. One estimate of a daily average of 3 British quarts per adult (3.4 liters) has been given for individuals in the Madras Province of South India by Pandit, Raghavachari, Rao, and Krishnamurti.[16] Hence, on the basis of the fluoride contents in Delhi and Boston water, if the average daily water consumption of an individual in Delhi were 3 to 4 liters, while a Boston resident of comparable bodily characteristics consumed only one liter, the Delhi citizen would consume in a day 6 to 8 times as much fluoride from drinking water as the Bostonian, i.e., 0.72 to 0.96 mg fluoride for the Delhi resident, in contrast to 0.12 mg for the Bostonian. Expressed in another way, the Delhi citizen would ingest from his water supply containing 0.25

p.p.m. fluorides, as much fluoride as an individual in the temperate zone would receive from a water supply containing 0.75 to 1.0 p.p.m. fluorides. Yet our data indicated fluoride levels for Delhi teeth comparable to those of individuals in temperate zones who have consumed waters containing 2.5 to 3.5 p.p.m. fluorides during tooth development, which on the basis of an average water intake of 1 liter would be a daily ingestion of approximately 2.5 to 3.5 mg.

Thus it would seem, on the basis of the best approximations justifiable with the present information, that there are two or three possible ways to explain the above contrast: (1) The Delhi resident received somewhere in the neighborhood of a third of his daily fluoride intake from the water supply and two-thirds from other sources, if he utilized fluorides at a comparable rate to the resident of a temperate zone; or (2) the Delhi resident retained a much higher percentage of ingested fluorides if there were no other source of fluorides than the water. Both of these factors may have operated so combined that there was both an additional source of fluorides and a more efficient retention of fluorides by the body.

The Bombay residents consumed a water supply containing, on the basis of the analysis of a single sample, in the neighborhood of 0.04 p.p.m. fluorides. Thus, if a Bombay resident were to obtain as much fluoride from water as a Boston citizen he would have to consume daily about 3 times as much as the Bostonian. Yet the fluoride contents of the Bombay enamel and dentin were 3 to 4 times as high, respectively, as the Boston enamel and dentin. The Bombay residents' fluoride levels in enamel and dentin could only be explained on the basis of a daily intake of approximately 1.2 to 1.9 mg or a much higher rate of absorption and retention than among Boston citizens. On the basis of the estimated water consumption of 3.4 liters used by Pandit *et al.*,[16] a Bombay resident would only ingest 0.14 mg daily from the water supply, or about one-tenth of the amount to be ingested on the basis of the fluoride contents of the enamel and dentin.

These comparisons appear to demonstrate with clarity that other sources of fluoride must be considered than the water supply, or that these Indian nationals retained a higher percentage of ingested fluoride than residents in temperate zones for whom metabolic data have been reported. Two possible dietary influences on the amount of fluoride absorbed have been described. In numerous animal experiments, increases in the level of calcium in the diet caused appreciable decreases in the percentage of fluorides absorbed from the intestinal tract[19–22] A suggestion was made that scurvy-like symptoms were induced in guinea pigs by the ingestion of sodium fluoride.[23] In the evaluation of the toxic manifestations of high fluoride ingestion, Pandit *et al.*[16] considered the influences of diet on the amount of fluoride absorbed. They concluded that variations in calcium intake probably had not influenced the incidence of mottled enamel in their subjects, but they felt that variations in the ingestion of vitamin C between communities might have been the cause of variations in incidence between communities with comparable levels of fluoride in the water. The possible influence of either of these factors on the results reported in this paper cannot be evaluated without further information.

One example has been described in the literature where the major source of fluoride came from food.[24] In this survey of the inhabitants of Tristan da Cunha, an appreciable incidence of the mild degrees of mottled enamel was noticed, even though the water supply contained around 0.1 p.p.m. of fluoride. Analyses of the enamel and dentin indicated fluoride values approximately the same as in communities where the water contained 1 p.p.m. fluorides.[25] It was postulated that the fluoride was provided by the high fish consumption in that area; in addition, the low calcium intake in that community may have caused individuals to absorb a higher percentage of the ingested fluorides.

We know relatively little about the fluoride content of various Indian foods nor the rate of consumption of the various items in the diet, although these are obviously areas which need to be explored intensively in view of the findings reported in this paper. However, it is known that sea salt prepared by drying sea water is widely used in India as the source of sodium

chloride, both for cooking purposes and table use. Since various samples of sea salt contained an average of 67 per cent sodium chloride, 50 per cent more sea salt would have to be consumed than refined table salt in order to supply the same amount of sodium chloride. In addition, in view of the high temperatures in India, and the higher water consumption, it is likely that the sodium chloride intake per individual is appreciably higher than in the temperate zone. However, in order to ingest enough fluoride entirely from sea salt containing 40 p.p.m. to obtain as much as an individual in the temperate zone would from a liter per day of water, containing 2.5 to 3.5 p.p.m. of fluoride, or 2.5 to 3.5 mg fluoride, it would be necessary for an individual in Delhi to consume somewhere between 63 and 88 grams of the sea salt daily. If, on the basis of our above approximations, one-third of the ingested fluoride came from the Delhi water supply, the amount of sea salt required to supply the additional two-thirds would be between 42 and 58 g per day, or a total of 28 to 38 g sodium chloride per day. These appear to be improbable levels for the human consumption of this material. By the same mode of calculation, a Bombay resident in order to obtain the remaining nine-tenths of the possible fluoride ingested would need to consume somewhere between 26 and 44 g of sea salt per day.

It is possible that there may be other high fluoride sources in the diet for which we are presently unable to account. The amount of fluoride contributed by tea during tooth development could not be evaluated at present in this study, although it was probably negligible. High tea consumption after the completion of tooth development would cause no significant alteration in the fluoride content of the enamel and dentin. Fish consumption among Indian non-vegetarians may have been appreciable in Bombay, but would be negligible in an inland area such as Delhi. A full survey of the typical diet of residents in these areas and of their fluoride excretion would be necessary in order to make a thorough evaluation of this puzzling problem.

Our studies on the fluoride content of Indian teeth add some additional information to the data of Pandit *et al.*,[16] who observed bone lesions in 387 adults out of a total of 1,192 examined in areas with water supplies containing 1.2 to 2.8 p.p.m. fluoride. They estimated that the ingestion of water-borne fluorides by these individuals varied from 9.4 to 24.0 mg per day. No estimation was made of fluoride intake from other sources, such as tea, fish, and sea salt. In contrast to these studies, Leone *et al.*[26] made two thorough clinical surveys of 116 individuals in Bartlett, Texas, where the water supply contained 7.6 to 8.2 p.p.m. fluoride. At the first survey in 1943, all subjects had been residents for 15 years or more. In 1953, all available subjects were reexamined. At the same time, 121 subjects were studied in the nearby community of Cameron, where the water supply contained 0.4 to 0.5 p.p.m. fluoride. The incidence of mottled enamel was high among the Bartlett residents, but was not observed among those from Cameron. Unlike the Indian studies, no evidence of disability due to bone abnormalities was observed in Bartlett. Obviously, the amounts of fluoride ingested in Bartlett must have been well in excess of the estimated lower levels at which bone lesions were observed in the Indian study. This comparison points to the likelihood that the subjects in the Pandit[16] survey received fluoride from other sources than water or that they absorbed a much higher percentage of ingested fluoride than did the Bartlett residents. This observation seems to indicate the need for a careful study of fluoride metabolism among residents in communities of India with low-fluoride water supplies and others where there are appreciable quantities of fluoride, to determine the reason for these differences between the Bartlett-Cameron surveys and Pandit's observations. Such a survey would of necessity have to include analyses of representative foodstuffs and an investigation of the approximate amounts of each fluoride-bearing food in the Indian dietary.

These current studies do not indicate whether the high fluoride content of the teeth from Delhi and Bombay was the only factor responsible for the great resistance to tooth decay among the Indian people. From a developmental standpoint, other trace elements sup-

plied by the sea salt may have been incorporated into the teeth during development at sufficiently high levels to alter the susceptibility to dental caries. This is a facet of the dental caries problem that needs extensive investigation, both at a laboratory level with experimental animals and by further studies with clinical material in areas where the sea salt consumption is high. Another factor which may contribute to the low caries incidence in India is the type of oral environment resulting from the ingestion of high carbohydrate diets composed to a large extent of relatively unrefined cereals with practically no soluble carbohydrates. However, the possibility of some influence upon dental caries incidence through the consumption of other trace elements or by the type of oral environment does not negate the conclusion that the high fluoride content of the Indian teeth is to a large extent responsible for the high caries resistance. At present, there are insufficient data available on the use of sea salt as a source of fluorides in human nutrition to justify any more than preliminary clinical trials on the use of sodium chloride with added fluorides as a procedure for the partial control of dental caries.

## SUMMARY

The enamel and dentin of teeth from individuals in Delhi and Bombay had a much higher fluoride content than would be expected in view of the low fluoride content of the water supplies in these communities. The fluoride values for the enamel and dentin of Boston teeth were in the same low range as has been reported for the teeth of individuals in other low-fluoride communities in the temperate zone.

Only part of the difference in fluoride content between the teeth of Boston individuals and those of Delhi and Bombay can be explained by the probable higher water consumption among the Indian citizens. The remainder of the difference would appear to be due to an additional source of fluoride in the diet, with sea salt as a logical possibility, or to a higher rate of absorption and utilization of the ingested fluorides, or to some combination of these two factors.

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### *The Biotic Community*

"I am firmly of the opinion that man is not paramount on the planet by divine right, though he may be apical in many ways to the pyramid of life. I do not see a planet concreted over its land surfaces to provide living and factory space for an immense human population nourishing itself and supplying all its needs synthetically. Human life is going to depend on plant life for a long time yet, and in far more ways than its value as an efficient conversion agent.

"Man, by his great powers of adaptation, can be and is a member of many biotic communities from Tropic to Arctic, but civilized man has tended to remove himself from the community and be predatory upon it; in other words, it is the familiar story of exploitation of natural resources or what we have so often called 'development.' Nevertheless, the organic philosophy has gained much ground and has linked up with the ecological concepts of biotic community. The problem is seen quite clearly now: How can we return to be members of biotic communities without going back to being savages? How can we prevent civilization from being self-destructive? We have had half-bakes from Rousseau onward who have 'gone back to nature,' and fine asses they have made of themselves! The ecological philosophy of community is unlikely to put straws in anyone's hair or send him out to eat grass. It would ask for knowledge before action, and the knowledge that would accurately foretell consequences. That knowledge would allow us actively to repair and rebuild natural communities which we see have creative and accretive properties. Thereafter our exploitation could be controlled so that we should not cut into capital, not go past the community's power to reconstitute and regenerate. This would be conservation through wise use, based on understanding of the physiology of biotic communities which constitute our environment."

—F. Fraser Darling: "The Ecology of Man." *Am. Scholar* 25: 41, 44–45, 1955–56.

# Practical Methods for Preparing Diets Low in Sodium and High in Protein

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IT IS generally recognized that the restriction of sodium in the diet is beneficial in many cases of hypertension and heart disease. A slight or moderate diminution in the salt intake is, however, seldom effective, a fact which accounts for much of the contradictory evidence in this field. Therefore, the attainment of a diet markedly low in sodium, but without diminution of other dietary factors, is of considerable importance to the physician and to the dietitian, as well as to the patient.

In a little-known manual by one of the pioneers in this field, Allen[1] gave detailed directions for preparing a diet low in salt. These included boiling some vegetables "in three changes of water, using abundant water and discarding it after each boiling . . . . To a limited extent the process can be applied to meat." Even though the sodium content of the various foods was not known, and the efficiency of the thrice-boiling procedure was not controlled, the results, according to this investigator, were quite good.[2] The subject of salt-restricted diets, however, remained a controversial one. With the advent of the Kempner rice diet,[3] the question arose as to the explanation for its effects. The most commonly accepted explanation was that this diet owed its efficacy to its low sodium content. The Kempner diet consists of rice, fruit, fruit juices, sugar, vitamins, and iron. Fluid is restricted. The diet furnishes about 2000 calories and about 15 to 25 grams of protein. The sodium content is estimated at about 100 to 150 mg.[4] It is thus seen to be low in protein, water, and calories, as well as in sodium.

The Kempner rice-fruit diet is quite difficult to maintain because of its monotony, but it does appear to be effective in many cases, if carried out rigorously.[3,4,5] Another objection to it is its low content of protein, far below the Sherman standard of 1 gram of protein per kilogram of body weight, which is usually considered a suitable mark at which to aim. An intake much less than this may lead to protein starvation, with unfortunate consequences. The Kempner diet, providing 15 to 25 grams, is certainly low in protein, and more than one investigator has remarked on the danger of continuing such a ration for a considerable length of time. Dole and his group[6] have shown that, "The reduction of blood pressure following restriction of dietary sodium was found to be independent of tenfold variations in the ration of dietary protein." In their patients, a restriction of dietary sodium was found to reduce the systolic and diastolic blood pressures by 12 ± 7.4 per cent. Some of the diets of their patients contained large amounts of protein, as much as 70, 90, or 100 grams per day for several weeks.

Our studies were stimulated by the success of Dr. George G. Ornstein in formulating and producing a diet extremely low in sodium, with a satisfactory protein content, and possessing variety and palatability.[7] Ornstein's plan comprised the selection of foods low in sodium and the removal of much of the sodium from other foods by repeated extraction by boiling them in three changes of water. Later he found that extraction with a large volume of cold water for several hours was apparently just as effective as boiling. The most effective procedure for accomplishing this remained

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to be determined, that is, the optimum extraction period, the optimum temperature, and other technical conditions. The present experiments were undertaken to attempt to answer these questions. In this work we have had the constant support and advice of Dr. Ornstein, which we gratefully acknowledge.

## METHODS[8]

### *Sampling and Treatment of Samples*

In all experiments, direct contact of the material with the hands was avoided.

(*a*) *Beef, steaks, chops, liver, veal cutlet, fish, and cheese:* In general, a two- to four-pound sample was utilized as starting material. Alternate slices were taken from the bulk and used as samples, the remainder as control. Fat, where present, was separated as completely as possible and all bones were removed prior to treatment. The samples were placed in ten times their weight of distilled water and allowed to soak in the refrigerator at 5° C for a period of 18 to 24 hours (Table I).

(*b*) *Legs and breast of fowl:* One whole, intact leg of a pair from the same fowl was used as sample, the other leg as control. Breast meat was cut in half—one piece for sample, the other as control. Treatment was the same as for (a).

(*c*) *Cream, milk, and eggs:* Samples of homogenized, bottled milk were pooled and thoroughly mixed; aliquots were taken for experimental treatment. Cream was dialyzed in Visking casing against ten times its weight of 3 per cent lactose; milk was dialyzed against distilled water. Stirring of the solutions did not alter the results significantly. Eggs, after mixing until homogeneous, were treated similarly, dialyzing them against distilled water.[9]

### *Analysis*

Following soaking (or dialysis), samples and controls of the solid materials were homogenized in a Waring Blender, dried to constant weight at 105°C. and defatted for 48 hours by extraction with anhydrous ether. The residue was ground and re-dried, and a 750-mg portion was extracted with 25 ml of 0.75 *N* nitric acid.[10] After an extraction period of five days, aliquots were taken and determinations of sodium and potassium made on the Janke flame photometer. Naturally, the liquid foods did not require the preliminary treatment.

TABLE I

The Effect of Duration of Soaking* on Sodium Removal from Beef

| Time | Average per cent removal |
|---|---|
| *hr* | |
| 6 | 43 |
| 8 | 55 |
| 12 | 58 |
| 24 | 63 |

* All samples were approximately 100 g and were soaked in ten times their weight of distilled water.

## RESULTS

The results obtained by the procedure outlined above are listed in Table II.

The values listed under the heading Sodium Control are those which were found by analysis of our control material. These are, in several cases, different from values listed in earlier reports.[11] We attribute this variation, in part, at least, to the source of the foods analyzed. For instance, eggs obtained from different regions showed a variation of nearly 100 mg sodium per 100 g egg. Such variations were noted in a great diversity of foods. Even samples of beef taken from different parts of the same piece varied to some degree.

The handling of samples was essentially quantitative, but *minimal removal* values are also listed. These minimal values represent sodium removals which can be expected even when allowance is made for touching of food with hands, the use of tap water in extractions, etc. This might occur when untrained persons are following the outlined procedure. Preliminary investigations revealed that maximal removal of sodium could not be obtained unless samples were soaked for a period of eighteen to twenty-four hours (Table I). *Maximal removal* is here an operational term which includes considerations of the limitations imposed on the housewife by the lack of laboratory facilities, and, further, considerations with regard to palatability, appearance, etc. In this connection, it was found that grinding of the meat before soaking would effect as much

TABLE II

Removal of Sodium from Foods

| Sample | Time of soaking | Sodium control | Removal | | | Aver. amount of Na remaining |
|---|---|---|---|---|---|---|
| | | | Max. | Min. | Aver. | |
| | *hr* | *(mg/100 g)* | % | % | % | *mg/100 g* |
| | | *Meat—Fowl* | | | | |
| Calf liver | 18 | 51 | 48 | 33 | 40 | 31 |
| Chicken leg (skin intact) | 24 | 66 | 41 | 5 | 27 | 48 |
| Chicken breast | 24 | 56 | 70 | 40 | 55 | 23 |
| Chicken liver | 24 | 78 | 51 | 6 | 26 | 58 |
| Lamb chop | 18 | 75 | 91 | 61 | 78 | 17 |
| Pork chop | 18 | 40 | 44 | 19 | 28 | 29 |
| Steak—top round | 24 | 43 | 73 | 52 | 63 | 15 |
| Turkey leg | | | | | | |
| Skin removed | 18 | 115 | — | — | 45 | 63 |
| Skin slit | 18 | 97 | — | — | 20 | 78 |
| Skin intact | 18 | 94 | — | — | 16 | 79 |
| Veal cutlet | 18 | 77 | 73 | 67 | 73 | 21 |
| | | *Fish* | | | | |
| Cod fillet | 24 | 59 | 67 | 56 | 59 | 24 |
| Halibut steak | 18 | 52 | 43 | 30 | 38 | 32 |
| Salmon steak (frozen) | 18 | 39 | 23 | 18 | 29 | 28 |
| | | *Dairy* | | | | |
| Cream cheese (Philadelphia) | 18 | 321 | 94 | 92 | 93 | 22 |
| Eggs—hard boiled | | | | | | |
| Without shell | 18 | 146 | 55 | 52 | 54 | 67 |
| Shell intact | 18 | 142 | | (No removal) | | |
| Milk | 6 (dialysis) | 48 | — | — | 52 | 23 |
| | 18 (dialysis) | 42 | — | — | 71 | 12 |
| Cream | 18 (dialysis) | 32 | — | — | 80 | 6 |

as 90 per cent removal, but in view of the loss of palatability and the difficulty of handling such material for further cooking, the high removal rate was sacrificed in favor of increased esthetic appeal.

Alternate and auxiliary treatments, such as freezing and thawing or exposure to ion-exchange resins, for example, were discarded, since these methods only slightly increased removal of sodium and were found impractical and tedious. It should be noted that physical factors influence the rate of removal to a considerable extent. Thus, the skin over the leg of the turkey presents a barrier to sodium extraction. If it is slit or removed, a larger amount of sodium is removed than if left intact. Lamb and veal permit the highest removal of sodium among the muscle meats, as might be expected from the tenderness of the meat of young animals. The average sodium removal from cod, halibut, and salmon was 59, 38, and 29 per cent, respectively. Whether this is related to their initial sodium content, 59, 52, and 39 per cent, to their fat content, 0, 5, and 15 per cent, to their water content, 83, 75, and 65 per cent, respectively, or to texture, is a question which awaits further experimentation.

## CLINICAL FEATURES

The clinical effects of such a dietary regimen are illustrated in Table III, which lists results with several typical patients and reveals the striking clinical benefits of a dietary restricted to foods which have been lowered in sodium content or are naturally low in that element. That is, in addition to the selection of foods low in sodium, some of their foods were either extracted with water or were dialyzed. No medication was used. Thus far, the appearance of none of the ill effects commonly attributed to the Kempner regimen has been detected;

TABLE III

Electrolyte and Nitrogen Excretion in the (24-Hour) Urine Following the Use of Very Low Sodium Diets, and Their Effect upon Blood-Pressure

| No. and sex | Weights* *kg* | | | Na | | K | | Cl | | Total N | Blood pressure* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before | | After | *mg* | *meq* | *mg* | *meq* | *mg* | *meq* | *g* | Before | After |
| 1M | 69.5 | 69.5 | 70.0 | 92 | 4.0 | 2693 | 68.9 | 207 | 5.8 | 9.41 | — | — |
| 1M | 69.1 | 70.4 | 69.1 | 83 | 3.7 | 3695 | 94.5 | 826 | 23.3 | 12.38 | 240/140 | 160/100 |
| 2F | 70.7 | 71.6 | 70.7 | 214 | 9.3 | 1784 | 45.6 | 930 | 26.2 | 6.05 | — | — |
| 2F | 70.7 | — | 72.7 | 255 | 11.1 | 1867 | 47.6 | 1130 | 31.9 | 7.27 | 234/130 | 161/96 |
| 3M | 72.8 | 70.9 | 71.8 | 190 | 8.3 | — | — | 1490 | 42.0 | — | — | — |
| 3M | 71.8 | 72.9 | — | 240 | 10.4 | 3686 | 94.3 | 334 | 9.4 | 14.27 | 169/118 | 148/106 |
| 4F | 52.9 | 53.0 | 56.8 | 344 | 15.0 | — | — | 970 | 27.4 | 7.81 | 250/111 | 230/101 |
| 5M | 68.3 | 68.7 | 66.7 | 353 | 15.4 | 3190 | 81.6 | 613 | 17.3 | 12.33 | 215/146 | 201/122 |
| 6M | 82.3 | 83.2 | 84.3 | 475 | 20.7 | 1503 | 38.4 | 574 | 16.2 | 11.97 | 201/123 | 136/92 |
| 7F | 77.0 | 76.0 | 75.7 | 1679 | 73.0 | 3052 | 78.1 | 2912 | 82.1 | 9.80 | 236/119 | 164/92 |
| 8F | 66.4 | 66.6 | — | 177 | 7.7 | 2965 | 75.8 | 216 | 6.1 | 9.80 | 172/94 | 174/93 |
| 9M | 62.5 | 64.8 | 64.1 | 171 | 7.4 | 2457 | 62.9 | 1634 | 46.1 | 8.86 | 226/133 | 145/105 |
| 10M | 67.8 | 67.8 | 69.1 | 91 | 4.0 | 2548 | 65.2 | 396 | 11.2 | 10.72 | 190/120 | 110/80 |
| 11M | 56.9 | 58.1 | 59.0 | 288 | 12.5 | 1088 | 27.8 | 466 | 13.1 | 8.24 | 212/132 | 145/108 |
| 12M | 66.7 | 66.6 | 65.4 | 501 | 21.8 | 3351 | 85.7 | 1365 | 38.5 | 12.11 | 231/142 | 209/140 |

* Weights and blood pressure measurements are from the records of Drs. G. G. Ornstein and L. Lercher. The middle weight column refers to weights at the time analyses were made, the "before" and "after" columns record weights on the preceding and following visit, respectively, and vary considerably as to time elapsed.

rather, patients have reported a gradual disinclination toward foods with a high sodium content and finally, a distaste for untreated foods. In all cases reported, the maintained high dietary nitrogen did not hinder the lowering of blood pressure and shrinkage of heart size, but tended toward establishment of a feeling of well-being and a general lessening of tension which parallels a diverse food intake.

It is assumed that the excretion of sodium, most of which is by way of the urine, is very nearly equal to the intake, i.e., that these patients were in approximate sodium balance. This assumption is based on the observations that (1) normally, and even in partial starvation, the body's ability to store salt is very limited and sodium balance rapidly occurs,[12] and (2) these patients showed no edema or marked gain or loss of weight. It is common knowledge that a gain in weight, with or without edema, accompanies retention of salt; and usually a loss of weight occurs with a deficit of salt. However, edema may also occur in the "sodium depletion syndrome" as a result of decrease in urine volume when kidney function is affected. None of these patients had renal involvement. It is, therefore, fair to conclude that, in these cases, the 24-hour urinary output of sodium is very nearly a measure of the intake. In this study the range of the 24-hour sodium output was 85 to 1679 mg of sodium per day, with three values below 100 and all, except one, 501 mg or less. The usual output of sodium on a mixed diet is of the order of 2000 to 4000 mg; therefore, this is indeed a marked diminution in the sodium excretion. The atypical output of sodium of Patient 7F (1679 mg) might have been caused by an inadvertent deviation from instructions.*

It is generally recognized that normal adult individuals on mixed diets, with but slight daily variation in the protein content, are in nitrogen equilibrium. Negative balances may occur in starvation, wasting diseases, or on diets having an imbalance in the essential amino acids. When any of these occurs there is usually a loss of weight. These patients consumed about 2500 calories per day and their weights remained fairly stable (Tables III and IV); hence the assumption of approximate

* These 15 24-hour samples were requested from 12 patients without any regard to the duration of the low sodium diet prior to collection. One factor which might have accounted for an occasionally high figure was the convenience, for the patient, of collecting the sample over the week-end when temptations are somewhat greater than usual.

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TABLE IV

Typical Example of a Week's Estimated Intake for One of These Patients

| | Carbohydrate | Protein | Fat | Total calories |
|---|---|---|---|---|
| | g | g | g | |
| Monday | 401 | 81 | 129 | 3176 |
| Tuesday | 275 | 71 | 120 | 2535 |
| Wednesday | 263 | 55 | 78 | 2029 |
| Thursday | 298 | 60 | 112 | 2509 |
| Friday | 213 | 59 | 87 | 1924 |
| Saturday | 230 | 53 | 115 | 2230 |
| Sunday | 279 | 87 | 107 | 2496 |

nitrogen balance, i.e., that the urinary nitrogen in these cases is an index of protein intake.

The nitrogen output in this study indicates an optimal protein intake or nearly so, i.e., a close approximation to the Sherman standard of 1 gram of protein per kilogram of body weight per day. This would be evidenced by a urinary nitrogen of about 0.16 g per kilogram. This value is reached or exceeded in five of the fourteen urines analyzed. The others ranged from 0.08 to 0.15 gram of nitrogen per kilogram. The average of all fourteen is 0.147 g of nitrogen per kg per day. The protein equivalent, therefore, ranges from 0.53 to 1.25 grams of protein, with an average of 0.92 g per kilogram body weight. It is possible, then, to have a diet which conforms closely to the recommended protein intake and at the same time is extremely low in sodium.

It is seen that satisfactory reductions in blood pressure occurred in every case except one. Number 8, with a blood pressure of 172/94 mm Hg, showed no effect, but all of the others reacted with reduction of both systolic and diastolic pressures. In some instances this effect was a substantial one.

This series comprises only a small number of individuals treated similarly with equally good results. No symptoms of sodium depletion were ever observed. However, it should be emphasized that the very low sodium diet was never prescribed for patients being treated with mercurial diuretics. None of these patients had renal complications. Chemical analyses of the blood urea, nitrogen, and creatinine were frequently performed, and no evidence of marked nitrogen retention was observed. The clinical details of some of these cases are discussed elsewhere[13] and a further report will appear soon.

## DISCUSSION

Our experiments show that simple extraction of various foods with water (or dialysis) for 24 hours will remove from 26 to 93 per cent of the sodium. Longer periods of time are of little value, and the time may be shortened to some extent by changing the extracting fluid at intervals. Many experiments were performed in which variations in the technique were employed, but none yielded sufficiently better results without impairing palatability to warrant further study.

It is self-evident that the simple extraction of a foodstuff with water will leach out not only the more soluble inorganic salts but also other water-soluble substances. In the case of the salts, since the greater proportion of sodium salts is extracellular, it was expected that this element would be removed more completely than potassium. This was not the case, and the removal of both was more or less parallel. However, since only those foods richest in sodium in the diet are subjected to extraction, and most foods have a considerable amount of potassium, there is no danger of a deficiency in potassium. This is clearly seen from Table III, where the potassium output in the urine exceeds the sodium output many times.

The loss of protein in the aqueous extract must be negligible. No determinations were made, but from the urinary nitrogen output it would seem that an adequate protein residue was available. This is important, since an intake of sufficient amounts of the indispensable amino acids is essential for good nutrition.

The loss of water-soluble vitamins was replenished in the clinical trials by the administration of a multivitamin supplement, but no attempt was made to supply trace elements. No doubt sufficient amounts of these were supplied in those foods which had not been extracted.

The method described is clearly of practical use and can be employed by any housewife. It is very simple to add approximately 10 volumes of water to a piece of meat or fish or a supply of vegetables and set it in the refrigerator over-

night, pour off the water just before mealtime and cook it. Spices, which are extremely low in sodium,[14] may be added as well as salt substitutes, notably ammonium glutamate. Dialysis of milk, cream, and eggs is not difficult, but probably will require a little practice. A Visking membrane (sausage skin) is moistened. One end is slipped under a rubber band which encircles the top of a large jar or beaker. Into the beaker is previously placed the required volume of water or 3 per cent lactose solution. The milk, cream, or eggs are then poured into the membrane through a glass funnel, and the open end of the membrane is slipped under the rubber band opposite the first end. If necessary, the main bulk of the filled sausage skin is gently pushed into place below the level of the fluid with a spoon. The jar is then placed in the refrigerator overnight. After emptying the dialysis tube, it may be washed and used again. The dialysis fluid at first used for milk and cream was a 3 per cent lactose solution, to avoid the loss of this sugar by dialysis. However, it was soon realized that this meant using and discarding a large amount of milk sugar, and that it was much simpler and more economical to add the sugar to the milk or cream after dialysis. The purpose of this is not only to provide the calories lost but especially to restore the flavor of the milk.

It seems to us that adherence to a diet incorporating moderate amounts of normally high sodium foods, treated as described above, will overcome most of the shortcomings of previous low sodium diets. When mixed with vegetables and fruits of naturally low sodium content,[11] such as potatoes, rice, cabbage, tomatoes, onions, peas, squash, beans, apples, lemons, oranges, pears, bananas, grapes, and grapefruit, these foods will provide an extremely varied and palatable diet with an adequate nitrogen intake. There are also on the market many low sodium foods, including bread, cake, matzoths, canned meats and vegetables, which add to the variety of such a diet. Most of these commercial foods are reliable, but some purchasers do not realize that "low salt" does not always mean low sodium, since other sodium salts are sometimes used for technical reasons. A government regulation to control this would be welcome.

It should be noted that all hypertensives do not require the same degree of sodium restriction. We believe it is wise to begin with as strict a regimen as possible, and gradually allow more and more sodium until the optimum is reached. In some regions the drinking water contains relatively high concentrations of sodium.[11] To meet this problem there are two possible recourses. The first is to drink distilled water. If aerated and chilled, this is quite palatable. The second is to use a de-ionizer. The de-ionizer* is a plastic bottle with an attachment, containing de-ionizing resins, through which tap water in the plastic bottle may be forced by inverting and squeezing the bottle. This has the advantage of being easily portable for use when the patient travels. Of course, low sodium water should be used in cooking as well as for drinking by these patients.

## SUMMARY

Methods for removing much of the sodium from various foods, by extraction and by dialysis, have been described. These are simple and may be employed by the average housewife. Maximum, minimum, and average removal values of sodium from various foods are tabulated.

A dietary containing as little as 100 to 500 milligrams of sodium with a satisfactory protein content may be made up of such foods, combined with other low sodium foods. It is palatable and variable, and aids in reducing blood pressure in many instances of hypertension.

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* The de-ionizer is made by Deeminac, Hartford, Conn.

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### *Public Interest in Science*

"Over the next decade, the public image of science, of medical research, and of the scientist may become more realistic. Research is more widely publicized through newspapers, magazines, radio, and television than at any time in the past. The public's avidity, spontaneous or artificially stimulated, for information on research is remarkable. The emergence of scientific writing for popular consumption as a clear professional journalistic specialty is a most encouraging development for the future. The development of a mature attitude by scientists toward their responsibilities and their rights in communicating to the public is another encouraging factor."

—J. A. Shannon. *J. A. M. A.* 160: 1030, 1956.

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### *Pitfalls of Science Publicity*

"The greatest lack in public opinion today is lack of information about what is possible and not possible in science. This sets my teeth on edge every time I read a scientific newsflash. I will quote one of many instances which I find distasteful: the use of the phrase 'cobalt bomb.' This is a technical term for a piece of medical equipment, but has suddenly become transformed into something to describe how a hydrogen bomb might be clothed. As a result, of the fifty million people in this country, forty-nine million nine hundred odd thousand have heard the words 'cobalt bomb,' but are helplessly confused between radioactive treatment and something that you blow people up with. The public must be well informed; and the public gets not only the government it deserves, but the newspapers it deserves."

—J. Bronowski. *Bull. Atomic Scientists* 12: 11, 1956.

# Nutritional Status of Selected Adolescent Children*

## I. DESCRIPTION OF SUBJECTS AND DIETARY FINDINGS

By MARGARET MCGREGOR HARD, M.S.† AND NETTIE C. ESSELBAUGH, PH.D.†

IN RECENT years the concept of nutritional status has developed to the realization that dietary intake alone is not an adequate indication of nutriture. Diet should be related to clinical and biochemical information obtained concurrently. In the State of Washington, one study on nutritional status has been reported.[1,2] This involved 10 families, including 48 people ranging in age from 3 to 77 years. The investigation was designed to study the effect of nutrition education on food habits. There also have been two studies on the dietary level of nutrients of families in two selected counties of the State.[3,4] Family diets only were considered. Nutritional studies specifically dealing with adolescent children have not been reported.

The work described herein is part of a comprehensive study of adolescent children involving dental and medical examinations, medical history, biochemical tests of the blood and urine, biomicroscopic observations and colored photography of selected tissues, basal metabolic rates, bone density roentgenograms, dietary history and a seven-day dietary record. Only the food-nutrient intake will be reported in this paper. Information concerning food patterns, medical, dental, and biochemical findings will appear in subsequent papers in this series.

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### PROCEDURE

*Selection of Areas for Study*

Two areas were chosen for a detailed nutritional study of the adolescent population—Snohomish County west of the Cascade mountain range and Yakima County east of the mountains in the central part of the State. The selection of these areas was based on four main considerations: tooth involvement, chemical composition of the drinking water, climate, and the presence of a non-migratory population.

*Tooth Involvement:* An estimate of the extent of decayed, missing, and filled teeth among teen-agers in Washington State, was made in a preliminary study[5] of native-born and -reared boys and girls who entered Washington State College as freshmen in the fall of 1950. Posterior bite-wing roentgenograms were taken of 612 students. Thirty-seven of the 39 counties were represented. The State as a whole may be described as having high tooth involvement. From Snohomish County, 24 students were studied. The average count of decayed, missing and/or filled teeth (DMF teeth) was 16.2, with an individual range of 12 to 20. From Yakima County, 34 students were examined. The average number of DMF teeth was 13.4, with a range of 5 to 19. These results indicated a slightly lower incidence of DMF teeth in the Yakima area than in Snohomish County. This difference in incidence of tooth decay was one of the deciding factors in choosing the two areas.

*Drinking Water:* In order to remove fluorine as a complicating variable, particularly in the dental phases, areas with a low concentration of fluorine in the drinking water were

chosen. Preliminary water analyses showed the city of Everett (representing Snohomish County) with 0.01 p.p.m. fluorine in the water and the city of Yakima (representing Yakima County) with 0.04 p.p.m., both levels below the 1.0 p.p.m. fluorine currently recommended for the control of dental caries.

*Climate:* Possible relationships between climatic conditions, such as the kind and amount of sunshine, and the nutriture of population groups have received limited investigation. With this in mind, the two areas selected varied widely in climatic characteristics. Snohomish County has a lower elevation, higher humidity and precipitation, and less sunshine than Yakima County (Table I).[6,7] Data are given for 1952 when the study was made.

TABLE I

Climatic Characteristics of the Areas Studied

| Climatic Characteristic | Everett | Yakima |
|---|---|---|
| Temperature | | |
| Average annual (° F) | 50.1 | 49.4 |
| Range | | |
| Highest (° F) | 92 | 102 |
| Lowest (° F) | 14 | −0 |
| Precipitation | | |
| Average annual (in.) | 22.6 | 6.1 |
| Number of days | 20* | 5* |
| Relative humidity (10:30 a.m., local time %) | 68* | 50* |
| Sunshine % of possible hours | 27* | 50* |
| Elevation (ft) | 120 | 1061 |

* Data for March 1952. Sunshine figures are for the vicinity of Everett and Yakima.

*Non-migratory Population:* To obtain an adequate sample of native-born and -reared children, areas of fairly large non-migratory population were necessary. Yakima (population 38,375) and Everett (population 33,807) were similar in this respect.

### *Selection of Subjects*

The subjects were 15- and 16-year-old boys and girls who had been born and reared in either Snohomish or Yakima County. Subjects did not qualify if they had been out of the County for more than 3 consecutive months at any one time.

The age groups were abitrarily defined $14^1/_2$ to $15^1/_2$ as 15-year olds, and $15^1/_2$ to $16^1/_2$ as 16-year olds. Age was determined to the nearest birthday.

All subjects were "normal" physically as defined by the research physician.

The co-operation of both prospective subject and parents was assured before the child was finally accepted for the study.

About 125 subjects were studied in each of the two areas. There were almost equal numbers of boys and girls in each age group in each area.

### *Collection of Dietary Data*

After a subject was accepted for the study, the nutritionist interviewed both the subject and the adult in charge of the home. The forms for recording the subject's dietary intake were explained, the method of quantitating intake was demonstrated, and the importance of accuracy was stressed.

Each subject recorded his or her food intake for seven consecutive days. Household measures and size of pieces in inches were used to make the records semi-quantitative. The records were collected daily through the school office and were examined by the nutritionist. If discrepancies appeared, the nutritionist checked them with the subject and/or the co-operator in the home. Evidence of continued inaccuracies in the dietary record was cause for dropping the subject from the study.

### *Calculation of Data and Statistical Treatment*

The seven-day dietary record of each subject was calculated for 12 nutrients, using the United States Department of Agriculture, Agriculture Handbook number 8[8,9] supplemented by information from Bowes and Church,[10] Bradley,[11] and Boyd, Eads and Sandstead.[12] Average daily means and standard errors of the means were obtained for boys and for girls from Snohomish County and from Yakima County. The mean daily intakes were compared with the respective National Research Council Recommended Allowances.[13] Analysis of variance was used for comparisons between groups.[14]

## RESULTS

### *Description of Subjects*

Sixty-three boys and 62 girls from Snohomish County participated in the study. Sixty-one boys and 62 girls were subjects from Yakima County.

The subjects from the two areas had similar nationality backgrounds. Ninety-two per cent of the Snohomish County subjects and 91 per cent of the Yakima subjects were of northern and western European extraction. Within this group, approximately 50 per cent were from Great Britain (English, Scottish, Welsh, and Irish). In the Snohomish area, about one-fourth were Scandinavian, while Germanic extraction was more evident in the Yakima area. Only a small proportion were of southern and eastern European and North American extraction.

The occupations of the fathers of the subjects were essentially similar in the two areas, although no attempt had been made to control this factor when choosing subjects. In both areas, a large proportion of the occupations fell in the groups craftsmen, foremen, kindred workers, and operatives and kindred workers as classified for the 1950 census on employment.[15] Sixty-six per cent were so classified for the Snohomish subjects, 34 per cent for the Yakima subjects. More of the Yakima fathers were professional and technical workers, farmers and farm managers, and sales workers. Although no records were taken of individual family incomes, the median incomes for Snohomish and Yakima counties were similar.[15]

Ninety-six per cent of the Snohomish County subjects and 75 per cent of the Yakima County boys and girls were classified as urban. Subjects were arbitrarily classified as urban if their source of water was the city water supply. All others were classified as rural.

### *Urine Constituents and Hemoglobin Values*

Urine constituents and hemoglobin values may be indicative of the general health of the subjects. The mean specific gravity of fasting urine for the Snohomish County boys and girls was 1.024 and 1.022, respectively, and for the Yakima County boys and girls, 1.026 and 1.025, respectively. Albumin-free urine was observed for 98 per cent of the Snohomish subjects and 96 per cent of the Yakima subjects. One subject in Yakima County showed a trace of glucose in the urine.

The hemoglobin values for the boys from Snohomish and Yakima Counties were 14.6 and 15.0 grams per 100 ml of blood, respectively, and for the girls, 13.6 and 13.3 grams per 100 ml in the respective areas.

*Height-Weight Status.* The heights and weights of the subjects as compared with Baldwin and Wood standards[16] are summarized in Table II. More than one-fourth of the Snohomish County boys were classified as "tall." Fifteen per cent of the Yakima boys were "tall." The mean height of the 15-year-old boys was 67 inches, and of the 16-year-old boys 68.6 inches. The Baldwin-Wood respective mean heights are 65 inches and 67 inches. From these standards it appears that the Washington boys of these ages are somewhat taller than average. About one-fifth of the girls in both areas were "tall." The mean heights of both 15-year-old and 16-year-old girls were the same as the Baldwin-Wood means, 63 and 64 inches, respectively.

Slightly more of the girls than boys in both counties fell in the "10 per cent and over" underweight group. About one-fifth of the

TABLE II

Percentage Distribution of Heights and Weights by Area and Sex in Terms of Baldwin and Wood Standards

| | Snohomish County | | Yakima County | |
|---|---|---|---|---|
| | Boys (63) | Girls (62) | Boys (61) | Girls (62) |
| | % | % | % | % |
| Height | | | | |
| Short | 6.3 | 16.1 | 1.6 | 9.7 |
| Medium | 65.1 | 66.1 | 83.6 | 67.7 |
| Tall | 28.6 | 17.7 | 14.8 | 22.6 |
| Weight | | | | |
| Underweight | | | | |
| 10% and over | 17.5 | 20.9 | 18.0 | 22.6 |
| 5–9% | 22.2 | 24.2 | 19.7 | 11.3 |
| Normal weight | 34.9 | 25.8 | 32.8 | 29.0 |
| Overweight | | | | |
| 5–9% | 11.1 | 8.1 | 13.1 | 6.5 |
| 10% and over | 14.3 | 21.0 | 16.4 | 30.6 |

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girls were so classified. A rather high percentage of girls also were "10 per cent and over" overweight: 21 per cent of the Snohomish girls and 31 per cent of the Yakima girls.

more boys fell in the fair to poor channels as compared to the standards.

The auxodrome ratings (Table III) indicate the relative developmental advancement of the

TABLE III

Percentage Distribution of Wetzel Grid Ratings by Area and Sex

| | Snohomish County | | Yakima County | | Wetzel Standards | |
|---|---|---|---|---|---|---|
| | Boys (63) | Girls (62) | Boys (61) | Girls (62) | Boys | Girls |
| | % | % | % | % | % | % |
| **Channel Rating** | | | | | | |
| $A_4$; Obese | 1.6 | 14.5 | 8.2 | 12.9 | 3.9 | 7.5 |
| $A_3$, $A_2$; Stocky | 7.9 | 12.9 | 8.2 | 22.6 | 9.5 | 11.1 |
| $A_1$, $M_1$, $B_1$; Good | 68.3 | 58.1 | 62.3 | 45.2 | 70.6 | 55.8 |
| $B_2$; Fair | 14.3 | 9.7 | 13.1 | 12.9 | 11.3 | 15.7 |
| $B_3$, $B_4$; Borderline and Poor | 7.9 | 4.8 | 8.2 | 6.4 | 4.7 | 9.8 |
| **Auxodrome Rating** | | | | | | |
| −2% | 11.1 | — | 9.8 | — | | |
| 2%–15% | 22.2 | 9.7 | 14.8 | 14.5 | | |
| 15%–67% | 36.5 | 46.8 | 37.7 | 56.5 | | |
| 67%–82% | 23.8 | 37.1 | 29.5 | 24.2 | | |
| 82%–98% | 6.3 | 6.5 | 8.2 | 4.8 | | |

TABLE IV

Average Daily Intake of Nutrients by Area and Sex

| Nutrient | Snohomish County | | Yakima County | |
|---|---|---|---|---|
| | Boys (63) | Girls (62) | Boys (61) | Girls (61) |
| Calories | 3181 ± 90.13* | 2213 ± 67.13* | 3119 ± 67.65* | 2048 ± 57.86* |
| Protein (g) | 108.9 ± 3.22 | 75.9 ± 2.54 | 101.2 ± 2.60 | 71.8 ± 2.76 |
| Fat (g) | 146.2 ± 5.53 | 100.2 ± 3.82 | 141.3 ± 4.68 | 91.9 ± 3.40 |
| Carbohydrate (g) | 361.7 ± 9.88 | 251.6 ± 7.52 | 375.4 ± 7.93 | 229.9 ± 6.22 |
| Calcium (g) | 1.64 ± 0.07 | 1.05 ± 0.04 | 1.41 ± 0.06 | 1.0 ± 0.04 |
| Phosphorus (g) | 2.03 ± 0.07 | 1.33 ± 0.05 | 1.87 ± 0.07 | 1.27 ± 0.04 |
| Iron (mg) | 16.4 ± 0.48 | 11.2 ± 0.41 | 16.5 ± 0.47 | 10.7 ± 0.38 |
| Vitamin A (IU) | 6939 | 4929 | 6678 | 4649 |
| | 3.8413 ± 0.0295† | 3.6927 ± 0.0290† | 3.8246 ± 0.0276† | 3.6674 ± 0.0358† |
| Thiamine (mg) | 1.59 ± 0.04 | 1.10 ± 0.04 | 1.62 ± 0.06 | 1.02 ± 0.03 |
| Riboflavin (mg) | 2.86 ± 0.12 | 1.93 ± 0.08 | 2.55 ± 0.10 | 1.84 ± 0.08 |
| Niacin (mg) | 19.0 ± 0.63 | 13.1 ± 0.55 | 18.1 ± 0.61 | 13.0 ± 0.81 |
| | 72 | 69 | 74 | 52 |
| Ascorbic Acid (mg) | 1.8550 ± 0.0287† | 1.8372 ± 0.0308† | 1.8710 ± 0.0271† | 1.7186 ± 0.0285† |

* Standard error of the mean.

† Geometric mean and the standard error of its logarithm were used to decrease skewness in these populations.

The height and weight values were also compared with Wetzel's standards[17] (Table III). The percentages of boys in the good physique channels ($A_1$, $M_1$ and $B_1$) more closely resembled the standard than did the percentages of girls in these channels. Although a higher percentage of girls fell in the obese ($A_4$) and stocky ($A_3$ and $A_2$) groups,

subjects. About equal percentages of boys and girls were standard or advanced, that is, in or above the 67 per cent developmental level or auxodrome. When the ratio of developmental age to actual age was calculated, 65 per cent of the boys and 58 per cent of the girls had a ratio of 1 or greater.

Wetzel[18] has defined the "undernourished"

child as one who falls in the $B_2$, $B_3$ or beyond channels with a lagging auxodrome and a heat output of −7 to −12 per cent below grid standards. According to this definition, 14 (10 girls and 4 boys, 5.6 per cent) of the 248 subjects could be said to be "undernourished."

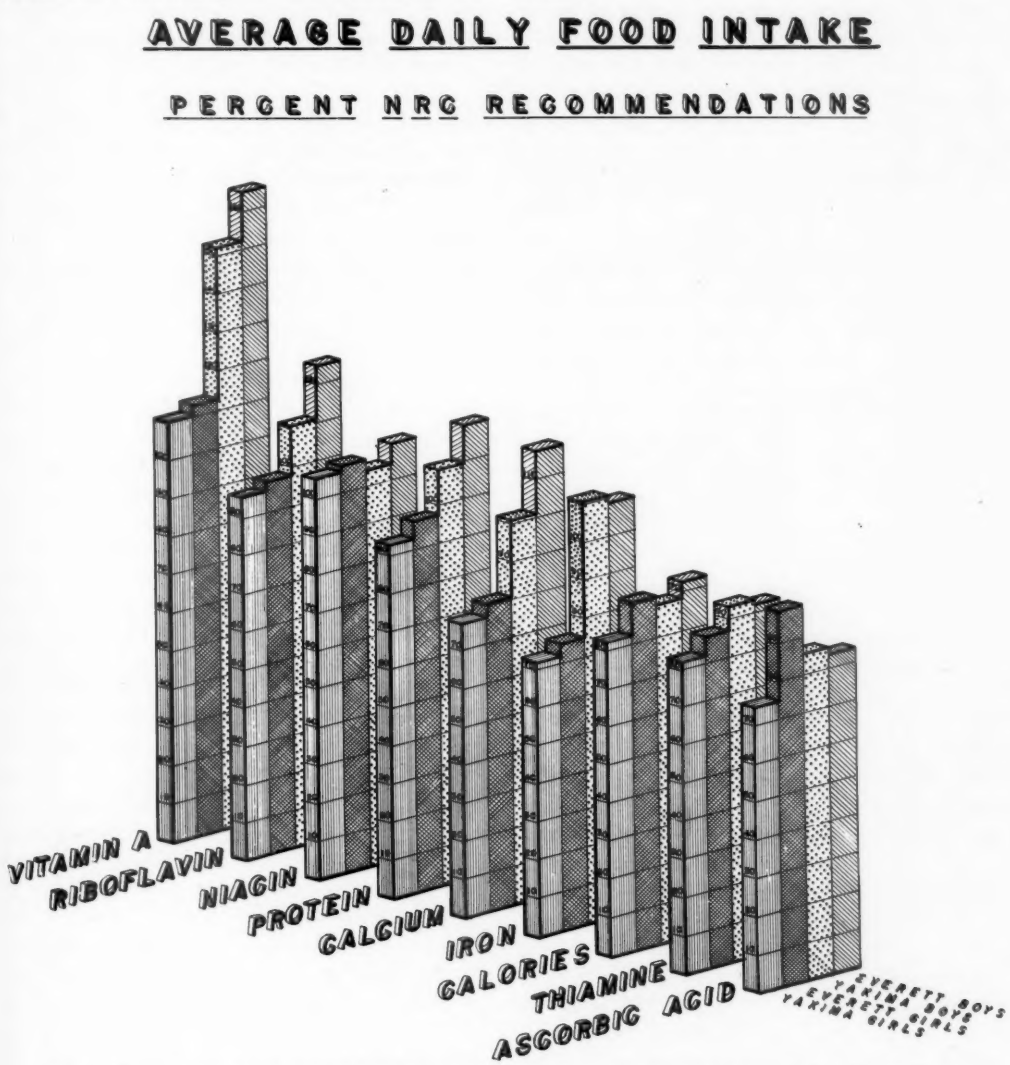


Fig. 1. Comparison of the average daily food intakes of selected adolescent children with the National Research Council Recommended Allowances.

*Nutrient Intake of the Subjects*

Table IV gives the average daily intake of 12 nutrients—calories, protein, fat, carbohydrate, calcium, phosphorus, iron, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid—for the boys and for the girls in the two areas studied.

Since the consumption of calories, carbohydrate, thiamine, ascorbic acid, calcium, and iron appears to be low in variable amounts for area and sex, analyses of variance were calculated for age, sex, and area for the intake of these nutrients. No significant difference was

TABLE V

Distribution of the Average Daily Intake of Calcium, Iron, Thiamine and Ascorbic Acid by Area and Sex

| *grams* | Snohomish County Boys (63) % | Snohomish County Girls (62) % | Yakima County Boys (61) % | Yakima County Girls (61) % |
|---|---|---|---|---|
| | *Calcium* | | | |
| Under 0.500 | — | 4.8 | — | 4.9 |
| 0.500–0.699 | 3.2 | 14.5 | 3.2 | 19.7 |
| 0.700–0.899 | 3.2 | 14.5 | 11.5 | 16.4 |
| 0.900–1.099 | 3.2 | 14.6 | 11.4 | 18.1 |
| 1.100–1.299 | 20.6 | 22.6 | 19.7 | 21.4 |
| 1.300–1.499 | 15.8 | 24.2 | 13.1 | 14.8 |
| 1.500–1.699 | 15.9 | 4.8 | 19.7 | 3.2 |
| 1.700–1.899 | 11.1 | — | 9.9 | 1.6 |
| 1.900–2.099 | 3.2 | — | 4.9 | — |
| 2.100–2.299 | 11.1 | — | 1.6 | — |
| 2.300–2.499 | 4.8 | — | — | — |
| 2.500 and over | 7.9 | — | 4.9 | — |
| | *Iron* | | | |
| *mg* | | | | |
| Under 6.0 | — | — | — | 1.6 |
| 6.0– 7.9 | 1.6 | 14.5 | — | 11.5 |
| 8.0– 9.9 | — | 24.2 | 3.3 | 32.8 |
| 10.0–11.9 | 6.3 | 30.6 | 6.6 | 26.2 |
| 12.0–13.9 | 15.9 | 11.3 | 18.0 | 13.1 |
| 14.0–15.9 | 23.8 | 8.1 | 16.4 | 8.2 |
| 16.0–17.9 | 25.4 | 8.1 | 19.7 | 3.3 |
| 18.0–19.9 | 9.5 | 1.6 | 16.4 | 3.3 |
| 20.0–21.9 | 9.5 | 1.6 | 14.8 | — |
| 22.0–23.9 | 1.6 | — | 3.3 | — |
| 24.0–25.9 | 3.2 | — | — | — |
| 26.0 and over | 3.2 | — | 1.6 | — |

| *mg* | Snohomish County Boys (63) % | Snohomish County Girls (62) % | Yakima County Boys (61) % | Yakima County Girls (61) % |
|---|---|---|---|---|
| | *Thiamine* | | | |
| Under 0.60 | — | 1.6 | — | — |
| 0.60–0.79 | 1.6 | 12.9 | — | 16.4 |
| 0.80–0.99 | — | 19.4 | 1.6 | 36.1 |
| 1.00–1.19 | 12.7 | 35.5 | 8.2 | 27.9 |
| 1.20–1.39 | 19.0 | 11.3 | 26.2 | 9.8 |
| 1.40–1.59 | 17.5 | 14.5 | 24.6 | 6.6 |
| 1.60–1.79 | 17.5 | 3.2 | 18.0 | 3.3 |
| 1.80–1.99 | 20.6 | 1.6 | 6.6 | — |
| 2.00–2.19 | 7.9 | — | — | — |
| 2.20–2.39 | 1.6 | — | 6.6 | — |
| 2.40–2.59 | 1.6 | — | 3.3 | — |
| 2.60 and over | — | — | 4.9 | — |
| | *Ascorbic Acid* | | | |
| *mg* | | | | |
| Under 20 | — | 1.6 | — | 3.3 |
| 20– 29 | 6.3 | 8.1 | 1.6 | 9.8 |
| 30– 39 | 6.3 | 6.5 | 8.2 | 16.4 |
| 40– 49 | 4.8 | 4.8 | 11.5 | 14.8 |
| 50– 59 | 14.3 | 17.7 | 14.8 | 14.8 |
| 60– 69 | 15.9 | 9.7 | 9.8 | 18.0 |
| 70– 79 | 7.9 | 9.7 | 4.9 | 3.3 |
| 80– 89 | 12.7 | 9.7 | 8.2 | 3.3 |
| 90– 99 | 9.5 | 4.8 | 13.1 | 1.6 |
| 100–109 | 3.2 | 3.2 | 4.9 | 4.9 |
| 110–119 | 4.8 | 4.8 | 3.3 | 3.3 |
| 120–129 | 1.6 | 8.1 | 1.6 | 3.3 |
| 130–139 | 1.6 | 1.6 | 4.9 | 1.6 |
| 140–149 | 3.2 | 1.6 | 8.2 | — |
| 150–159 | 3.2 | 1.6 | 3.3 | 1.6 |
| 160 and over | 4.8 | 6.5 | 1.6 | — |

found between the intakes of 15- and 16-year-olds, either boys or girls. The differences between the intakes of boys and girls were highly significant for all nutrients except ascorbic acid. Area differences corrected for sex were not significant, but area differences within sexes were found for calcium and ascorbic acid. The calcium intake of the boys was higher in Snohomish County. The girls in Yakima County consumed significantly less ascorbic acid (at the 1 per cent level) than Snohomish County girls.

On the whole, the boys from Washington State compare favorably with boys in the Northeast region.[19] The Washington girls, however, tend to be lower in nutrient intake than girls of 13 to 15 years in the Northeast region. This is particularly true for iron. The average daily intake was 11.2 ± 0.41 mg and 10.7 ± 0.38 mg for Snohomish and Yakima counties, respectively, while Maine reports an average intake of 14.1 ± 3.6 mg, New York, 13.0 ± 3.4 mg, and Rhode Island, 11.7 ± 2.8 mg. Similarly, the Washington girls were lower in vitamin A, thiamine, riboflavin, niacin, and ascorbic acid. The Yakima County girls, especially, had diets low in ascorbic acid compared to girls in Maine, New York, and Rhode Island. Wilcox,[20] however, reports intakes for non-rheumatic 13- to 15-year-old girls which are similar to those reported in this paper.

A comparison of the average daily intakes with the National Research Council Recommended Allowances[18] is shown in Figure 1. It will be noted that the girls' diets tend to be poorer than the boys' in most nutrients. This difference was particularly marked for calcium and iron. Thirty-nine per cent of the Snohomish girls and 46 per cent of the Yakima girls consumed less than 10 mg of iron (Table V); 23 per cent and 33 per cent, respectively, consumed less than 0.8 gram of calcium. Both groups of boys and the Yakima girls were low in ascorbic acid. Thirty-two per cent of the girls were getting less than 50 mg per day of ascorbic acid, while 34 per cent of the boys had less than 60 mg per day. Many subjects had low intakes of thiamine (Table V). Other dietary surveys[19–21] have indicated that iron, calcium, and ascorbic acid may be low in the diets of adolescent children.

These data on nutrient intake raise certain pertinent questions in regard to the nutritional status of this selected group of Washington adolescent children. The full significance of these dietary findings cannot be realized without reference to other criteria of nutritional status. Interpretation of nutrient intake in conjunction with medical and biochemical findings will be discussed in subsequent reports.

## SUMMARY

Food nutrient intakes from seven-day dietary records are reported for 248 15 and 16 year-old native-born and reared Washington boys and girls selected from coastal (Snohomish County) and inland (Yakima County) areas of the State.

Age group differences for the 12 calculated nutrients were not significant. The boys in Snohomish County consumed significantly more calcium than did the Yakima County boys. The ascorbic acid intakes of the Yakima girls were significantly less than those of the Snohomish County girls. Other differences between nutrient intakes in the two areas were not significant.

The dietary intakes of the girls tended to be poorer than those of the boys. This was particularly true for iron, calcium, and ascorbic acid. Both boys and girls were low in ascorbic acid when compared to the National Research Council Recommended Allowances.

According to the Baldwin-Wood standards, the Washington boys tend to be taller than average for their age. The mean height of the girls was similar to the Baldwin-Wood mean. A higher percentage of the girls than of the boys were overweight and were in the obese and stocky Wetzel physique channels. Sixty-five per cent of the boys and 58 per cent of the girls had a Wetzel developmental ratio of 1 or greater.

The specific gravity, albumin content and glucose content of the fasting urines were "normal." Average hemoglobin values for the boys in Snohomish and Yakima Counties were 14.6 and 15.0 grams per 100 ml of blood,

and for the girls, 13.6 and 13.3 grams per 100 ml in the respective areas.

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# Observations on the Urinary Excretion of Thioctic Acid

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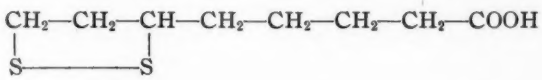
THIOCTIC ACID, 6,8-dithiooctanoic acid, is a biologically active substance which may occur in various molecular forms including the dithiol, the monosulfoxide and conjugates. Substances with the biological activity of thioctic acid occur in a large variety of plant and animal tissues.[1] Thioctic acid has a coenzymatic function in the oxidative decarboxylation of $\alpha$-keto acids[2,3,4] and it was suggested that in photosynthesis a conjugate of thioctic acid is the substance in which the quantum absorbed by the plant pigments first appears as chemical bond energy.[5] It is an essential nutrient for certain micro-organisms and is active in very low concentrations.[6–8] Its structural formula is as follows:



Attempts to produce a deficiency in animals by dietary means or with antagonists have not been successful in our hands, probably because the intestinal microflora or the animal itself may have the ability to synthesize thioctic acid.[9] The latter is suggested by experiments in which the thioctic acid content of the developing chick embryo showed a continued increase from the first to the 21st day.[9] However, DeBusk and Williams[10] have recently reported a growth-promoting effect of DL-thioctic acid (also known as DL-$\alpha$-lipoic acid) for chicks and rats. Beneficial effects of DL-thioctic acid in the management of hepatic coma in man,[11–13] and a reduction of the thioctic acid activity in the livers of rats having abnormal ketogenesis have been reported.[14]

This paper reports the results of a study made of the urinary excretion of thioctic acid, and some observations on a new form of thioctic acid found in the urine.

## BIOASSAY

Thioctic acid activity was measured microbiologically by the pad plate assay using *Corynebacterium bovis*[15] except in certain instances when *Streptococcus faecalis* was used as indicated.[16] The activity of fresh urine was 10 to 180 times as much by the *C. bovis* assay as with the *S. faecalis* assay (Table I). The *S. faecalis* assay value of urine stored several days at 4° C increased to essentially the value obtained with *C. bovis* which had not changed. Thioctic acid and thioctic acid monoxide are equally active for these two organisms. It appears that in fresh urine thioctic acid activity is in an unidentified form that changes during storage to thioctic acid, as identified by bioautographs and solvent counter-current distribution.

TABLE I

The Growth Response of *Streptococcus faecalis* and *Corynebacterium bovis* to Human Urine

| Sample (DL-thioctic acid orally) | μg equivalent DL-thioctic acid per ml | |
|---|---|---|
| | *C. bovis* | *S. faecalis* |
| Normal | 0.32 | 0.005 |
| 0–1 hr after 100 mg | 164 | 5.1 |
| 1–6 hr after 100 mg | 54 | 0.33 |
| 0–24 hr after 10 mg | 2 | 0.03 |

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### THE EFFECT OF THE ADMINISTRATION OF DL-THIOCTIC ACID ON THE THIOCTIC ACID ACTIVITY OF THE URINE

The thioctic acid activity in the urine of several species (Table II) varied over a three-fold range. When DL-thioctic acid was administered the thioctic acid activity in the urine was increased (Tables III and IV), yet only one biologically active form was found by paper chromatography and solvent countercurrent distribution. The per cent recovery based on bioactivity varied with the route of administration. For example, when 5 mg of DL-thioctic acid was administered to 250-g rats the amount recovered in the urine following intraperitoneal injection was 0.6 per cent;

TABLE II

The Thioctic Acid Activity of Urine from Several Species

| Animal | Average Thioctic Acid Activity per ml (μg equivalent of DL-thioctic acid) |
|---|---|
| Man | 0.20 |
| Dog | 0.44 |
| Rat | 0.21 |
| Rabbit | 0.30 |
| Horse | 0.60 |
| Cow | 0.52 |
| Sheep | 0.25 |

TABLE III

The Excretion of Thioctic Acid Activity in the Urine of Rats and Rabbits After Administration of DL-Thioctic Acid

| No. of Animals | Dose (mg DL-thioctic acid) | μg equiv. DL-thioctic acid in urine per animal | Recovery, | Urine Collection Period |
|---|---|---|---|---|
| (250 g avg) | | | % | *hr* |
| 1 rat | — | 3.5 (avg) | — | 0– 24 |
| 1 | 0.5 I.V. | 29 | 5.9 | |
| 1 | 5 I.V. | 294 | 5.9 | |
| 1 | 5 I.P. | 29 | 0.6 | |
| 3 | 15 I.P. | 51 | 0.29 | |
| 1 | 15 I.P. + 15 mg $B_1$ I.P. | 42 | 0.28 | |
| 1 | 25 I.P. | 40 | 0.16 | |
| 1 | 50 I.V. | 1630 (died 30 hr) | 3.2 | |
| 5 | 0.1 Subcut. | 11 | 7.5 | 0– 18 |
| 5 | 1.0 | 110 | 10.0 | |
| 5 | 5.0 | 280 | 5.5 | |
| (2 kilo avg) | | | | |
| 10 rabbits | — | 110 | — | |
| | 100 I.V. | 5040 | 5.0 | 24– 48 |
| | — | 80 | | 48– 72 |
| | — | 300 | | 72–144 |
| | 100 I.V. | 8000 | 8.0 | 144–168 |
| | — | 560 | | 168–192 |
| 2 | — | 1500 | | 0– 24 |
| | 500 I.V. | 10,000 | 1.7 | 24– 48 |
| | — | 400 | | 48– 96 |
| | 500 oral | 23,700 | 4.4 | 96–120 |
| | — | 2600 | | 120–144 |
| | — | 1100 | | 144–168 |
| 2 | — | 2000 | | 0– 24 |
| | 500 oral | 24,000 | 4.4 | 24– 48 |
| | — | 750 | | 48– 96 |
| | 500 I.V. | 20,000 | 3.8 | 96–120 |
| | — | 2900 | | 120–144 |
| | — | 900 | | 144–168 |

I.V.—intravenously
I.P.—intraperitoneally
Subcut.—subcutaneously
$B_1$—vitamin $B_1$

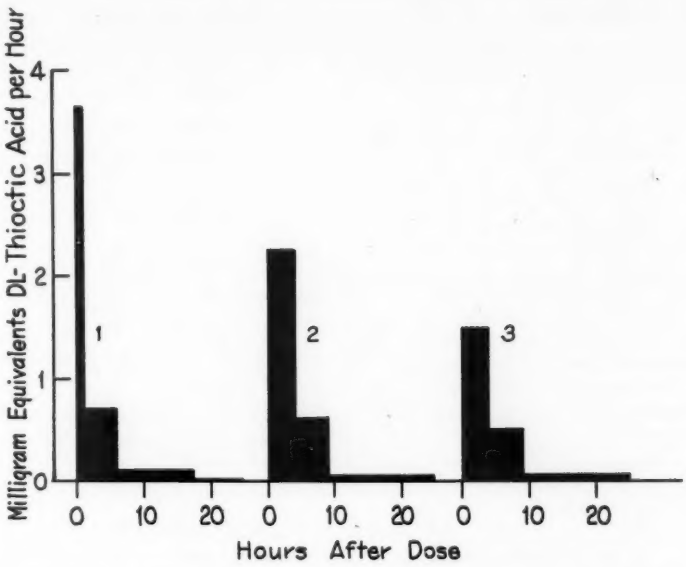


Fig. 1. The urinary excretion of thioctic acid activity after oral administration of DL-thioctic acid with and without thiamine to adult human males. (1) 100 mg DL-thioctic acid. (2) 50 mg DL-thioctic acid (3) 50 mg DL-thioctic acid + 50 mg thiamine hydrochloride.

intravenous, 5.9 per cent; subcutaneous, 5.5 per cent. The size of the dose did not appreciably alter the per cent recovery in the urine, nor was there a marked difference among species.

TABLE IV

Urinary Excretion of Thioctic Acid Activity by Human Adult Males Following Oral Administration of 10 mg of DL-Thioctic Acid

| Subject | μg equivalent DL-thioctic acid excreted in 24-hour period | | |
|---|---|---|---|
| | Before Dosage | After Dosage | |
| | | Trial 1 | Trial 2 |
| 1 | 169 | 576 | 1181 |
| 2 | 220 | 870 | 760 |
| 3 | 204 | 756 | 1051 |
| 4 | 153 | 567 | — |
| 5 | 156 | 694 | 929 |
| 6 | 171 | 714 | — |

In adult male humans the average urinary recovery of a 10-mg oral dose of DL-thioctic acid was 6.3 per cent, and the thioctic acid activity of the urine had returned to normal within eight hours after administration of the dose (Fig. 1). When thiamine was simultaneously administered, there was no change in the rate or amount of excretion of thioctic acid activity.

The low recovery of thioctic acid activity in the urine after administration of DL-thioctic acid suggested that storage of the material in the organs might be occurring. Therefore, several organs from rabbits that had received DL-thioctic acid were assayed for their thioctic acid content and compared with those of untreated animals (Table V). No appreciable differences in the thioctic acid content were found.

## PROPERTIES OF A NEW FORM OF THIOCTIC ACID IN URINE

The thioctic acid activity in urine was purified about 50-fold by solvent countercurrent distribution (Fig. 2) and chromatographic adsorption on magnesol. Further purification was made difficult by the continuous change in the nature of the material during treatment and storage. Usually the conversion, which was essentially quantitative based on biological activity, was complete in about ten days. Conditions to prevent this were not found. The ultimate conversion

TABLE V

The Effect of the Administration of DL-Thioctic Acid to Rabbits on the Thioctic Acid Activity in Various Organs

| Organ | μg Equivalent DL-thioctic acid per organ | |
|---|---|---|
| | Injected | Control |
| Liver | 0.13, 0.11 | 0.10, 0.08 |
| Kidney | 0.09, 0.05 | 0.09, 0.13 |
| Heart | 0.05, 0.10 | 0.07, 0.12 |
| Lung | 0.04, 0.03 | 0.03, 0.03 |
| Spleen | 0.02, 0.02 | 0.01, 0.01 |

Two adult female New Zealand rabbits were given 100 mg DL-thioctic acid intravenously three and five days before being sacrificed. Two control animals were untreated. The organs were homogenized and autoclaved three hours in 2.5 N $H_2SO_4$. The solutions were neutralized and assayed.

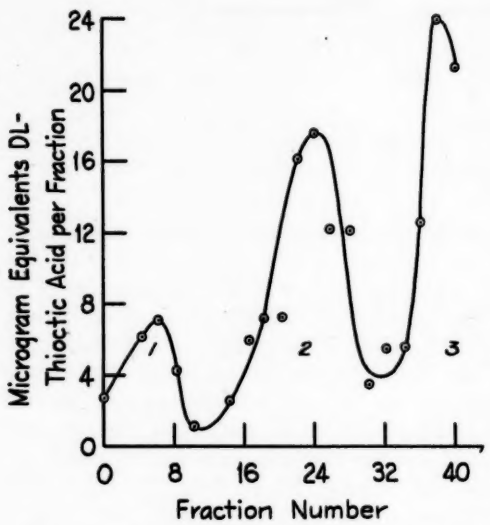


Fig. 2. Solvent counter-current distribution of urinary thioctic acid activity. System: n-butanol—0.5 M phosphate pH 3. Peak 3 (K = 10) is thioctic acid. Peak 2 (K = 1.7) is an unidentified form of thioctic in fresh urine which changes during storage to thioctic acid and a second unidentified form of thioctic acid, peak 1 (K = 0.2).

products appeared to be thioctic acid and a smaller amount of thioctic acid monoxide. These were identified by paper chromatography (Table VI) and by solvent counter-current distribution in the system of 0.5 M phosphate pH 7.3—chloroform. The distribution coefficients (K = concentration in organic phase ÷ concentration in aqueous phase) of

TABLE VI

$R_f$ Values of the Thioctic Acid Activity in Urine and Thioctic Acid after Certain Chemical Treatments

| Sample and Treatment | $R_f$ Values for Thioctic Acid Activity |
|---|---|
| DL-thioctic acid monoxide | — — 0.82 |
| DL-thioctic acid | — 0.68, 0.84 |
| DL-thioctic acid + 10 N HCl, 120° C, 6 hr. | — 0.72. 0.89 |
| DL-thioctic acid + 6 N NaOH, 120° C, 3 hr. | — 0.62 — |
| Fresh urine | 0.34 — — |
| Fresh urine + 10 N HCl, 120° C, 6 hr. | — — 0.80 |
| Fresh urine + 6 N NaOH, 120° C, 3 hr. | 0.29 — 0.79 (trace) |
| Urine stored 4°, 8 days | 0.40, 0.54, 0.69 |
| DL-dihydrothioctic acid | — 0.62, 0.77 |
| Purified thioctic acid activity from urine in liquid $NH_3$ | 0.32 — — |
| Purified thioctic acid activity from urine in liquid $NH_3$ + sodium | — 0.66, 0.80 |

thioctic acid and thioctic acid monoxide in this system are 0.5 and 0.1, respectively. After several days' storage of urine the major portion of the thioctic acid activity had a K of 0.6 and a small amount with K = 0.15. In stored samples of urine a second unidentified form of thioctic acid was found (Fig. 2, K = 0.2 and Table VI, $R_f$ = 0.54) which was characterized by its slight distribution into organic solvents. Whether this was a monoxide of the unidentified form of thioctic acid in fresh urine and gave rise to the thioctic acid monoxide on ultimate conversion or whether it was an intermediate in the conversion to thioctic acid was not determined.

The new form of thioctic acid in fresh urine was stable to autoclaving in strong alkali but was changed to thioctic acid during autoclaving in strong acids (Table VI). By sodium reduction in liquid ammonia it was converted probably to dihydrothioctic acid which during development on paper was oxidized to thioctic acid and thioctic acid monoxide (Table VI). The biological activity remained unchanged for *C. bovis* and increased for *S. faecalis* during sodium reduction in the same manner as occurred during storage. The microgram equivalents of DL-thioctic acid before and after re-

duction, respectively, were as follows: *C. bovis*, 165 and 134; *S. faecalis*, 0 and 121. These data suggest that the thioctic acid in urine was conjugated through a bond which was labile to acid and sodium reduction but which was stable to alkali. Such a linkage probably would not involve the carboxyl of thioctic acid but instead one or both of the sulfur atoms.

Thiamine and thioctic acid are both involved as coenzymes in the biological oxidation of pyruvic acid and $\alpha$-ketoglutaric acid. The availability of thioctic acid makes possible a new experimental approach to clinical states which are characterized by elevations in blood keto-acids, such as hepatic coma,[17,19] parenchymal liver disease,[18] and patients who have received fructose by infusion[18]. The present investigation indicates that a pathway may exist for the metabolism of thioctic acid in normal subjects.

## SUMMARY

The urine of several animal species, including man, contains an unidentified form of thioctic acid that supports the growth of *Corynebacterium bovis* but not *Streptococcus faecalis* on a propionate medium. The thioctic acid activity of the urine showed an increase followed by a return to normal during the first 24 hours after administration of DL-thioctic acid by several routes. Following this administration, the recovery of thioctic acid activity from the 24-hour urine ranged from 0.6 to 10 per cent of the dose administered, all in the form of the unidentified conjugate. The simultaneous administration of thiamine with DL-thioctic acid to man did not alter the thioctic acid activity in the urine. No storage of an injected dose in several of the viscera was detected. The thioctic acid activity in urine is conjugated probably through one or both of the sulfur atoms in a bond which is labile to acid or to sodium reduction but is stable to alkali. The use of thioctic acid in patients with elevations in blood keto-acids is discussed briefly.

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### *Perspective in Research*

"Research is not done only in the laboratory. It may be conducted at the bedside, in the operating room, and in the field of public health and epidemiology. It is not the place that counts. It is the perspective. It is the original mind asking a question and designing an experiment to find the answer. It should not be pebble picking—it should be the building of magnificent castles. I have no sympathy for the view that any kind of research is good. Research should advance a fundamental concept or it should have an obvious practical value and early application. Research is not gadgeteering. It is the pursuit of ideas. With the development of elaborate tools, like flame photometers, ultracentrifuges, angiocardiographs, ballistocardiographs, electron microscopes, electrophoresis, and isotopes, there has developed a small group who play their instruments for all they are worth. Having acquired the equipment, the buildings, the technicians, and the project grants, they go madly searching for ideas. They scrutinize grant applications if they are on research-allocation committees, they scan published reports, they rush to meetings, they write to their friends, and they ask visiting colleagues for ideas. This is obviously all wrong. Research should start from ideas, and then tools should be obtained, not vice versa."

—L. N. Katz. *J. A. M. A.* 160: 1137, 1956.

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### *Call to Nonconformity*

"I have given you the simple practical grounds for allowing scientists to be awkward, but I believe also that imaginatively and intellectually this is equally important. The sense of intellectual heresy is the lifeblood of our civilization. And the heresy of scientists cannot be confined to their science. Newton was thoroughly and rightly contrary in science, and he was also a thorough heretic in religious matters. For the same reason, people like Oppenheimer and Einstein are found to associate with such unreliable characters. You cannot say to scientists: 'When you get into the laboratory at nine in the morning you are going to become a dissenter; and when you go out at five-thirty you are going to become a citizen who touches his cap and is politically sound.' The intellect is not divided into these simple categories."

—J. Bronowski. *Bull. Atomic Scientists* 12: 13, 20, 1956.

# Effect of Food Intake on Amino Acids in Human Plasma

*By* E. Staten Wynne, ph.d.,* and Cora L. Cott, m.a.

In any investigation of free amino acids in human plasma, knowledge of the possible importance of the post-prandial status is desirable. If ordinary eating has an appreciable effect, blood must of course be collected following a relatively constant post-prandial period. Such a limitation is somewhat inconvenient; moreover, experience has demonstrated that fasting status cannot invariably be determined from statements of experimental subjects.

No published data are available on the influence of fasting on the concentration of individual amino acids in *untreated* human plasma. With microbiological assays of protein-free filtrates of plasma from children, Waisman and associates[1] reported no appreciable difference in levels of amino acids before and after eating. However, no details of the procedure were furnished, nor were any data given. In a study of seven amino acids in protein-free filtrates of whole blood from six adults, Charkey and co-workers[2] claimed that a 48-hour fast increased the levels of leucine and valine, but decreased those of arginine, lysine, methionine, threonine, and tryptophan. Inspection of their data, however, reveals that with methionine only two individuals exhibited a decrease on fasting, while three showed an increase. Likewise, arginine and lysine levels were increased after fasting in only two of the six individuals studied. Of the five amino acids reported to be decreased as a result of fasting, two failed to show any increase six hours after termination of the fast. Most of the amino acids showed a rather marked variation in levels among individuals, and apparently the data were not accorded statistical treatment.

Using microbiologic assays of 13 amino acids in unhydrolyzed rat plasma, Henderson, Schurr, and Elvehjem[3] claimed that the concentrations of most of the amino acids increased as the fasting period increased and reached maximum values in from 9 to 12 hours following the last food intake. However, control studies were not made on animals before, nor immediately after, they had been deprived of food; the earliest assay was carried out after three hours of fasting. Inherent variability among the groups of rats receiving the different treatments was stated to be of the order of ±10 per cent; but these data were not accorded adequate statistical analysis. It is difficult to interpret the findings of these workers, but it would seem that short-term fasting did result in an appreciable increase in the concentration of arginine, glycine, leucine, and lysine.

In this paper, studies are reported on microbiologic assays of amino acids in unhydrolyzed human plasma from blood collected both following an overnight fast and after subsequent food intake.

## METHODS

Blood was secured from healthy volunteers before, and one and three hours after, food intake. At the time of collection of the first specimen, no food of any kind had been taken for at least nine hours. Meals were composed of two eggs; ham, bacon, or sausage; half a cup of grits; two slices of buttered toast; jelly; and milk or coffee. At least five in-

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dividuals were used in the study of each amino acid. In some cases assays were made of plasma samples collected from the same individual on two or three occasions.

Blood was obtained aseptically by venous puncture and mixed immediately with sterile 0.1 M sodium oxalate in the ratio of 9 to 1. After separation of the plasma by centrifugation, appropriate amounts were incorporated into tubes of the previously sterilized amino acid assay medium of Henderson and Snell.[4] For each plasma sample, assays were conducted at one concentration level in triplicate or at two levels in duplicate. The final volume was 5 ml per tube in all cases. Arginine was assayed with *Streptococcus faecalis* ATCC 8043; tryptophan with *Lactobacillus plantarum* ATCC 8014; and glycine, histidine, isoleucine, and tyrosine with *Leuconostoc mesenteroides* P-60 ATCC 8042. The inoculum consisted of one drop per tube of a 1 to 20 dilution of a washed 24-hour culture from Difco micro inoculum broth, and incubation was for 48 hours at 30° C. Growth was estimated from turbidity measurements with a Klett-Summerson photoelectric colorimeter at a wave length of 655 mμ. By reference to standard curves constructed from data obtained with tubes containing known amounts of amino acid and incubated simultaneously with the samples, results were expressed as μg of amino acid per ml of plasma. It is recognized that simpler peptides as well as free amino acids may have contributed to the responses of the micro-organisms used.[5]

The data were examined for statistical significance by the *t* test and by analysis of variance. Differences were regarded as significant only when the value of P was less than 0.01.

## RESULTS

As seen from the data in Table I, the intake of food had no significant effect on plasma tryptophan, isoleucine, tyrosine, and glycine. Furthermore, statistical evaluation of the data by the *t* test revealed that of these four amino acids, only tyrosine exhibited significant variation ($P < 0.01$) in the fasting level from one individual to another. Analysis of variance confirmed the significance ($P < 0.01$) of differences in plasma tyrosine among individuals.

Analysis of the histidine data by the *t* test indicated that a significant increase following food intake was found only once in 13 experiments on eight individuals (Table I). The subject exhibiting this increase did so in only 1 of 3 experiments. However, analysis of variance failed to indicate significance (at the 1 per cent level) of food consumption on plasma histidine, or of variation of histidine level among individuals.

In 10 of 11 experiments on the same eight subjects, there was some elevation of plasma arginine after eating, although the increase was statistically significant by the *t* test in only four cases (Table I). Of these four instances, two occurred in the same individual (G. D.). However, on a third occasion this person failed to show a significant rise in arginine following food intake. Three hours after breakfast the overall mean plasma level for the 11 arginine experiments was increased over the fasting mean with $0.02 > P > 0.01$. Analysis of variance revealed the trend toward elevation of arginine following eating to be highly significant ($P < 0.001$), and also indicated that arginine, like tyrosine, exhibited a significant variation ($P < 0.01$) in level among individuals.

## DISCUSSION

The findings just detailed for arginine are in essential agreement with those of Charkey *et al.*,[2] who reported increases in this amino acid in three of six individuals six hours after termination of a 48-hour fast. On the other hand, our failure to detect any significant effect of food intake on tryptophan is contrary to the findings of these workers, who reported a decrease in this amino acid on fasting and an increase following termination of the fast. However, it should be pointed out that both fasting and post-prandial periods were different in the two studies. Furthermore, protein-free filtrates of whole blood were used by Charkey *et al.*,[2] while untreated plasma was employed in the present investigation.

In rats, Henderson *et al.*[3] found that levels of certain amino acids generally reached peak concentrations in from 9 to 12 hours after the last food intake. Though fasting periods

TABLE I

Microbiologically Available Amino Acids in Human Plasma[a] before Breakfast, and One and Three Hours after Breakfast

| | Tryptophan[b] | | | Isoleucine[b] | | | Tyrosine[b] | | | Glycine[c] | | | | Histidine[d] | | | | Arginine[d] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subject | Before | 1 hr | 3 hr | Before | 1 hr | 3 hr | Before | 1 hr | 3 hr | Before | 1 hr | 3 hr | P | Before | 1 hr | 3 hr | P | Before | 1 hr | 3 hr | P |
| F.S. | 19.1 | 20.1 | 19.2 | 6.2 | 6.4 | 9.2 | 8.8 | 11.8 | 11.5 | 24.5 | 18.4 | 20.8 | <.02 | 20.7 | 19.5 | 20.9 | >.10 | 26.3 | 39.3 | 34.5 | <.01 |
| G.D. | 17.7 | 20.4 | 16.8 | 5.3 | 7.1 | 7.5 | 9.1 | 10.1 | 13.4 | 21.0 | 22.5 | 25.5 | >.10 | 20.8 | 17.8 | 19.6 | >.10 | 17.6 | 22.0 | 29.5 | <.01 |
| | | | | | | | 12.5 | 13.2 | 12.0 | 21.8 | 18.5 | 25.2 | >.10 | 20.1 | 17.6 | 17.5 | >.10 | 14.3 | 25.4 | 24.1 | <.01 |
| | | | | | | | 13.0 | 14.0 | 15.2 | | | | | 17.9 | 18.6 | 21.2 | >.10 | 17.6 | 26.1 | 25.0 | >.10 |
| L.R. | 17.1 | 19.6 | 18.6 | | | | 12.3 | 8.8 | 8.7 | 26.2 | 20.1 | 18.6 | <.05 | 16.9 | 15.5 | 16.1 | >.10 | 15.1 | 15.8 | 25.5 | <.01 |
| E.S.W. | 15.5 | 14.5 | 18.8 | | | | 9.9 | 6.8 | 12.2 | 24.0 | 23.5 | 22.5 | >.10 | 21.3 | 17.8 | 20.9 | >.10 | 18.7 | 15.2 | 26.1 | >.05 |
| C.L.G. | 20.9 | 20.5 | 18.8 | 7.8 | 5.1 | 7.9 | 10.8 | 8.0 | 10.4 | 21.4 | 17.6 | 19.4 | <.05 | 21.5 | 19.5 | 18.5 | >.10 | 30.3 | 35.0 | 35.5 | >.10 |
| | | | | | | | 15.6 | 18.2 | 16.9 | | | | | 18.6 | 17.8 | 24.6 | <.05 | 22.0 | 22.4 | 26.4 | >.10 |
| N.M | 17.4 | 16.7 | 17.1 | | | | | | | | | | | 16.8 | 14.5 | 17.3 | >.10 | 15.9 | 18.9 | 25.1 | <.05 |
| M.T. | | | | 6.6 | 6.9 | 5.9 | 17.5 | 14.3 | 16.2 | | | | | 5.3 | 13.4 | 15.4 | <.01 | 13.6 | 10.3 | 12.5 | >.10 |
| | | | | | | | | | | | | | | 24.0 | 23.6 | 26.5 | >.10 | | | | |
| | | | | | | | | | | | | | | 17.2 | 14.2 | 14.4 | >.10 | | | | |
| P.F. | | | | | | | 17.5 | 22.3 | 18.9 | | | | | 20.0 | 18.0 | 17.6 | >.10 | 16.3 | 21.5 | 19.1 | >.10 |
| E.S. | | | | 5.0 | 4.6 | 7.2 | | | | | | | | | | | | | | | |
| Mean | 17.9 | 18.6 | 18.2 | 6.2 | 6.0 | 7.5 | 12.7 | 12.8 | 13.5 | 23.1 | 20.1 | 22.0 | >.10 | 18.5 | 17.5 | 19.3 | >.10 | 18.9 | 22.9 | 25.7 | <.02 |
| Standard Error | 0.75 | 1.0 | 0.37 | 0.49 | 0.41 | 0.53 | 0.92 | 1.36 | 1.0 | 0.82 | 1.0 | 1.19 | | 1.32 | 0.75 | 0.98 | | 1.7 | 2.74 | 2.1 | |

[a] As μg/ml of plasma, including free amino acid plus microbiologically available peptide.
[b] P >0.10 in all cases.
[c] P calculated from fasting value vs lowest value.
[d] P calculated from fasting value vs highest value.

in rats are not necessarily equivalent to those in humans, the fasting interval in the present investigation was also about 9 to 12 hours. If human subjects react as rats do, one might expect amino acid levels to be higher in the fasting state than after eating. As seen in Table I, a trend toward a decrease from a fasting peak was actually observed with glycine; however, in no instance did the *t* test show this decrease to be significant at the level of P = 0.01. Furthermore, analysis of variance failed to indicate a significant trend toward decrease of glycine after eating.

The findings reported here are not at variance with published information on the effect of ordinary eating on total amino acid nitrogen of human blood. Thus Hammett[6] found essentially no difference in amino acid nitrogen of blood drawn before or $3^1/_2$ hours after breakfast. Edgar[7] reported the average level of amino acid nitrogen in whole blood of 77 fasting diseased children to be 8.23 mg per 100 ml, while the average of 40 non-fasting diseased children was 8.97 mg per 100 ml, an increase of only 9 per cent. In the studies of Folin and Berglund,[8] amino acid nitrogen in plasma of fasting adults was 5.2 mg per 100 ml, while $5^1/_2$ hours after eating the level was 6.4 mg per 100 ml, a rise of 23 per cent.

The present data show rather marked variation in the levels of some amino acids among different individuals, and in the same individual tested at different times. In this connection it is of interest to point out the finding of Hammett[6] that amino acid nitrogen in one individual ranged from 3.6 to 6.1 mg per 100 ml, with values in different subjects from 3.1 to 7.2 mg per 100 ml. Analogous data of Edgar[7] revealed a range of 5.13 to 8.14 mg per 100 ml for one individual and 6.08 to 9.52 mg per 100 ml for different individuals.

SUMMARY

Levels of microbiologically available glycine, isoleucine, tryptophan, and tyrosine in unhydrolyzed human plasma were similar in blood obtained in the fasting state or after food intake. In 1 of 13 experiments histidine was significantly increased ($P < 0.01$) following eating. In 4 of 11 experiments on eight individuals, arginine was significantly elevated ($P < 0.01$) after food intake. Of the six amino acids studied, analysis of variance indicated significant variation ($P < 0.01$) among individuals for tyrosine and arginine only.

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# The Effect of Oral Dextran on Blood Glucose

*By* ROBERT H. JOELSON, M.D.*

DEXTRAN, a polysaccharide of high molecular weight, has shown some clinical usefulness as a blood substitute in the treatment of shock, and its metabolism after intravenous infusion has been the subject of considerable study. Little is known, however, of the influence of oral dextran on blood sugar levels. Bloom and Wilhelmi[1] fed this material to animal and human subjects and reported a slight but significant rise in blood sugar.

## PROCEDURE

Five subjects were given 400 ml of 5 per cent dextran. Unlike the dextran for intravenous use (mol. wt. 75,000), this was an unhydrolyzed product with an average molecular weight of 16,000,000.† Four of the subjects were mild diabetics; none required insulin. These might well be expected to show an exaggerated response in blood sugar if dextran is absorbed and metabolized as glucose. The fifth subject (E) was a man with organic hyperinsulinism whose severe chronic hypoglycemia could be expected to respond to even minimal amounts of carbohydrate which might be derived from the dextran.

All tests were done after a 14-hour fast, except for the subject with hyperinsulinsim who was tested after a three-hour fast. Blood sugars were drawn at 0, 1/2, 1, 2, and 3 hours. Determinations were done by the method of Somogyi, as modified by Nelson.

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## RESULTS

The results are depicted in Table I. It can readily be seen that no significant increase in blood sugar occurred in any patient. None of the patients showed any untoward effects. The patient with hyperinsulinism and hypoglycemia displayed no beneficial clinical response to the ingested dextran.

TABLE I

Blood Sugar Values in mg/100 ml in Five Human Subjects after Ingestion of 20 Grams of Crude Dextran

| Time | Subject* | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Fasting | 157 | 119 | 84 | 79 | 26 |
| 1/2 hour | 162 | 129 | 89 | 80 | 28 |
| 1 hour | 163 | 120 | 87 | 86 | 28 |
| 2 hours | 146 | 112 | 83 | 81 | 25 |
| 3 hours | 138 | 106 | 87 | 79 | 27 |

* A–D, diabetes; E, hyperinsulinism.

The results of this study indicate that unhydrolyzed high molecular weight dextran is not a readily available source of carbohydrate. Since the material is colorless, tasteless, and odorless and, when mixed with water, has the consistency of syrup, it might prove useful as a carbohydrate substitute, especially suitable as a vehicle for packing dietetic fruits for the diabetic.

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† The dextran used in this study was kindly supplied by Dr. Robert C. Hockett.

# Dental Survey of Selected Thai Children:

## NUTRITIONAL OBSERVATIONS

*By* Od Kridakara, b.d.s.,* Rith Boozayaangool, b.d.s.,* Isra Yuktananda, b.d.s.,* and J. F. Volker, d.d.s., ph.d.,†

Although numerous surveys have been made of the prevalence of dental caries in children, only a limited amount of information has been accumulated on Asiatic peoples. A recent review by Finn[1] refers to studies in China, Tibet, Malay, Mongolia, India, and the Philippines. No reference, however, is made to the prevalence of caries in Thailand. The data herein reported are the result of a clinical survey of the prevalence of dental caries in over 2300 selected Thai children and observations on their occlusion and gingival health. Approximately half of the children were from the capital city of Bangkok, located in the south central portion of the country; the remainder were from Chiengmai and Lampang in the northern hill country. Bangkok, particularly in the postwar period, has had considerable personal and commercial contact with western civilization, while Chiengmai and Lampang are relatively isolated.

### METHODS AND MATERIALS

The groups included in this study were attending school, kindergarten through high school. All examinations were made with mirror and explorer. Subjects ranged in age from 4 through 18 years and each clinician examined a random portion of each class and age group. At the end of each working day, the observations of the respective clinicians were summarized and compared. They were found to be in good agreement. This suggests that their individual standards of examination are comparable. Dental caries experience was recorded in terms of D.F.‡ (decayed and filled teeth). Care was taken in the charting so that information on both deciduous and permanent D.F. rates could be calculated for the mixed dentition groups. Gingival health was recorded as normal, fair, or poor. Children with gingivitis limited generally to the papillae or to an isolated area of the mouth were considered to have fair gingival health. They were cited as having poor gingival health when there was more extensive inflammatory or degenerative involvement of the tooth supporting structures. Occlusion was recorded as normal, fair, or poor. Children with pronounced Class II and III malocclusion and those having such conditions as pronounced open or cross bites were considered to have poor occlusion. It was felt that these cases were in acute need of orthodontic treatment for functional or esthetic reasons or both. Children were classified as having fair occlusion where the molar relationship approached the normal but had crowding or rotation or both of one or several teeth, or abnormal protrusion or spacing of the anterior teeth.

Since the City of Bangkok had a considerable number of children attending Chinese and Islamic schools, and since the dietary habits of the Chinese and Islamic peoples differ from those of the Thai, the decision was made to in-

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This survey was undertaken in 1951 when one of the authors (J.F.V.) was serving as a dental specialist affiliated with the U. S. State Department under provisions of the Smith-Mundt Act.

‡ Since interviews showed the number of permanent teeth missing because of caries to be very small, the decision was made to report caries prevalence as D.F. (decayed and filled) rather than as D.M.F. (decayed, missing and filled).

clude in the survey children from each group. These data are presented separately. Only those children from Thai language schools in Bangkok are compared with the children from Thai language schools in Chiengmai and Lampang.

## RESULTS

Table I shows a comparison of the dental health of Bangkok area children attending Thai, Chinese, and Islamic language schools. It will be noted that the prevalence of dental caries in the deciduous and permanent teeth, the gingival health, and the occlusion of the three groups of children are generally comparable. The only exception would seem to be the smaller percentage of Chinese children that are caries-free. There is also an indication that the gingival health of the Thai children is somewhat poorer than that of the Chinese and Islamic children.

TABLE I

Comparison of Dental Health of Bangkok Area Children in Thai, Chinese, and Islamic Language Schools

| Type school | No. examined | % Caries free | Average D.F.* deciduous teeth | | | Average D.F.* permanent teeth | | | Gingival health (%) | | | Occlusion (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5–7 yr | 8–10 yr | 11–13 yr | 8–10 yr | 11–13 yr | 14–16 yr | Normal | Fair | Poor | Normal | Fair | Poor |
| Thai | 552 | 7.6 | 10.3 | 5.1 | 0.7 | 2.9 | 4.0 | 5.1 | 46 | 35 | 19 | 43 | 33 | 24 |
| Chinese | 239 | 1.3 | 11.7 | 6.2 | 1.3 | 3.3 | 5.1 | 6.3 | 54 | 38 | 8 | 44 | 33 | 23 |
| Islamic | 225 | 3.5 | 9.8 | 6.0 | 1.4 | 2.4 | 3.8 | 5.8 | 47 | 43 | 10 | 42 | 35 | 23 |

*D. F.—decayed and filled.

Figure 1 compares the dental caries prevalence in the 552 Bangkok Thai children with 673 Chiengmai and 652 Lampang Thai children. Although only 8 per cent of the Bangkok children were found to be free of caries, 55 per cent of the Chiengmai children and 38 per cent of the Lampang children had not experienced tooth decay. It is obvious that the prevalence of caries in Bangkok at any age from 5 to 18 years is much greater than that observed in Chiengmai. The average child in Chiengmai has a deciduous D.F. of slightly less than 3 at six years of age and his Bangkok counterpart has a D.F. of approximately 10. At age 18, when Chiengmai school children have an average D.F. of 1.5, Bangkok school children have a D.F. of 5.5. In general, the caries attack rate in Lampang children parallels that found in Chiengmai. The only exception is the higher caries attack rate noted in the Lampang five-, six-, and seven-year-old groups. It is pertinent that the Lampang schools reported in this study included an American missionary school. This group had a rather higher caries attack rate and was largely responsible for the elevated value reported herein for young Lampang children.

The gingival health of Thai children attending Bangkok, Lampang, and Chiengmai schools is seen in Figure 2. It will be noted that in no instance does the percentage of children with normal gingiva reach 50 per cent. The overall gingival health of the Chiengmai children was poorer than that of the Lampang and Bangkok children. It was noted that a considerable number of the Chiengmai children showed evidences of dietary deficiencies. Cheilosis and tongue symptoms were commonly seen.

The occlusion of the Bangkok, Chiengmai, and Lampang children is recorded in Figure 3. In general, the occlusion of the Chiengmai children was superior to that of the Bangkok children. Approximately 60 per cent of the Chiengmai had normal occlusion, while only 15 per cent could be classified as being poor. In contrast, only 43 per cent of the Bangkok children had normal occlusion and 24 per cent had poor occlusion.

## DISCUSSION

The most significant finding in this study is the very high caries prevalence in Bangkok children. It is in excess of that reported by most observers of European and American children in comparable age groups. One possible explanation is that in this area the basic

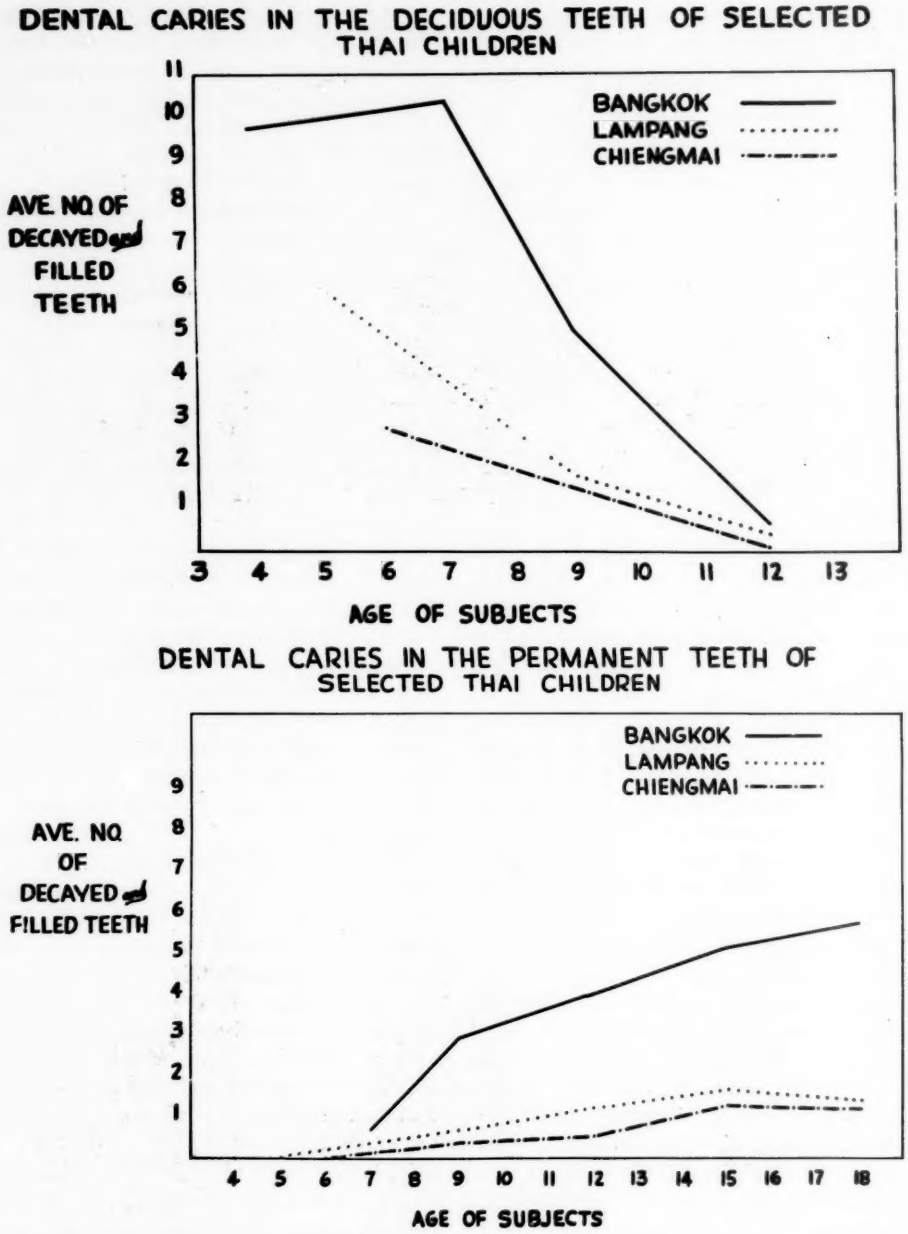


Fig. 1. Points on graph represent the averages for subjects in age groups covering three years. For example, point at age 6 represents the average for 5-, 6-, and 7-year-old children.

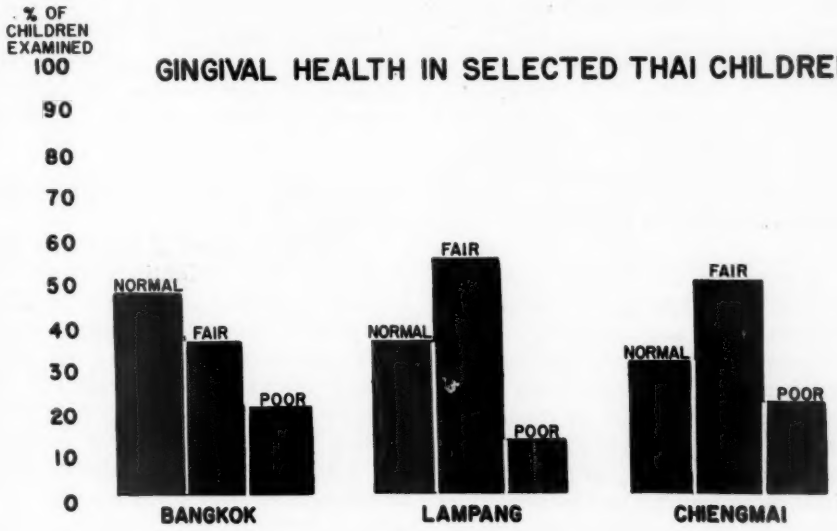


Figure 2

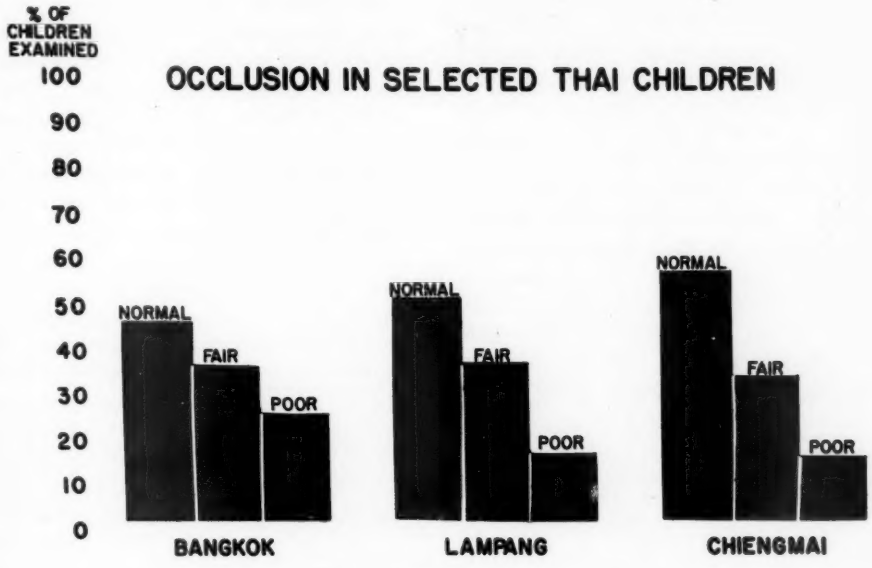


Figure 3

TABLE II

Sugar and Wheat Flour Consumption in Thailand

| Year | Amount in metric tons | |
|---|---|---|
| | Sugar* | Wheat flour† |
| 1945 | 7,270 | 100 |
| 1946 | 4,781 | 3,084 |
| 1947 | 3,274 | 5,246 |
| 1948 | 18,192 | 4,995 |
| 1949 | 28,424 | 10,210 |

* Home produced and imported.

† Imported (no appreciable home production).

Thai diet of rice, fruit, and fish has been replaced in part or supplemented by sugar and starch-containing foods and confections. This view finds some support in data accumulated from government sources relative to the sugar and wheat flour consumption in Thailand. This information is presented in Table II. It will be noted that for the five-year period, 1945 through 1949, sugar consumption increased by approximately 400 per cent, while wheat flour utilization increased from 100 metric tons to over 10,000 tons. From firsthand observation it would seem that the great majority of the increased amounts of sugar and flour was consumed by Bangkok area people. These data suggest that a rice, sugar, and wheat flour diet has considerable potential for producing dental caries. This general view finds support in observations reported on experimental animals, particularly the rat and hamster.

It is, of course, possible that the low caries susceptibility of the northern Thai children might be explained by the presence of fluoride in drinking water. During the examinations, special care was taken to detect mottling of the enamel. The only evidences of mottling were found in a small group of Lampang children from a limited area who drank water from a common well. Pictures of their dentition are available.

TABLE III

Dental Restorations in Selected Thai Children

| Location | No. of children | No. of permanent teeth | No. of cavities | No. of restorations |
|---|---|---|---|---|
| Bangkok | 552 | 12,023 | 2183 | 242 |
| Chiengmai | 673 | 14,401 | 625 | 24 |
| Lampang | 652 | 13,852 | 850 | 1 |

A final observation of interest is shown in Table III. It is indicative of the great need for dental services throughout Thailand. In Lampang, for example, 850 unrestored carious teeth were observed and only 1 restoration was noted in the 652 children examined. Even in Bangkok, where 552 children had 2183 teeth needing restoration, only 242 carious teeth had been restored. It is obvious that this unmet need for dental services calls for an expansion of the present dental education facilities.

## SUMMARY

Over 2000 Thai school children from 4 to 18 years of age were given dental examinations. Observations were made of caries prevalence, gingival health, and occlusion. The most significant finding was the high caries attack rate in the deciduous teeth of children living in the Bangkok area. It is suggested that this may be due in part to the increased sugar and wheat flour consumption.

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# *Letters to the Editor*

## Effect of a Synthetic Triglyceride on Lipid Metabolism

Dear Sir:

Previous reports from this laboratory[1-2] have indicated that the administration of unsaturated vegetable fats would produce a profound fall in plasma cholesterol and phospholipid, as compared to the level existing on diets containing equal amounts of saturated vegetable fats or certain animal fats. So long as *natural* fats were used, there was some question in our minds as to whether the lipid-lowering effect was attributable to the unsaturated fatty acid content *per se*, or whether the effect might be related, in part at least, to the sterol and/or phospholipid content of the administered fat.

In Figure 1 is shown the first study carried out with a chemically constant formula diet in which a synthetic triglyceride has been the source of the dietary fat. The particular fat in question was prepared by, and supplied to us through, the kindness of Dr. L. A. Goldblatt of the Southern Regional Research Laboratory, United States Department of Agriculture. Its fatty acid composition was oleic acid, 74 per cent; palmitic acid, 19 per cent; stearic acid, 5 per cent; and linoleic acid, 2 per cent. The 24-hour linoleic acid intake was approximately 2 grams. A prompt and profound decrease in plasma cholesterol occurred during the administration of the synthetic fat. Administration of 10 grams of cholesterol (emulsified with the formula) resulted in a very slight elevation of plasma cholesterol. Following discontinuance of cholesterol, there was some fall in plasma cholesterol and phospholipids. Substitution of saturated vegetable (coconut) oil for the synthetic fat resulted in a progressive rise of plasma cholesterol and phospholipids.

The foregoing is compatible with the concept that the plasma cholesterol and phospholipid levels are a function of the relative or absolute intake of essential fatty acids. It is postulated that plasma phospholipids and esterified choles-

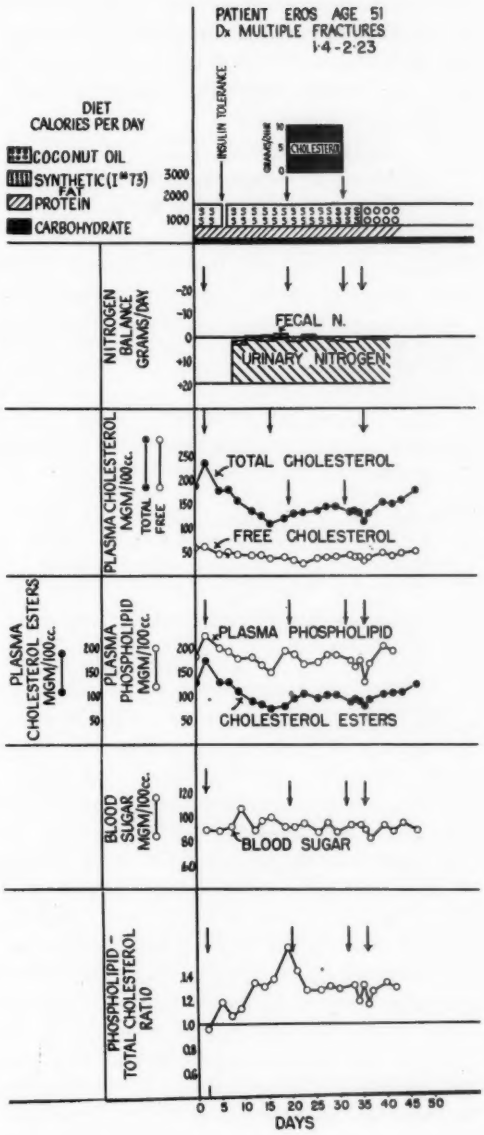


Fig. 1. Changes in plasma cholesterol and phospholipids during the intake of a synthetic triglyceride containing (per 24 hours) approximately two grams of linoleic acid. The shifts in phospholipid/cholesterol ratio are of interest.

Approximately 30 per cent of the administered cholesterol was absorbed (stool analysis).

terol represent a major part of the fatty acid transport system between liver, depots, and periphery. An adequate amount of essential acids is necessary to make this system function at maximal efficiency, with consequent reduction in unit concentration of circulating lipids. This hypothesis is currently being subjected to experimental evaluation.

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Frederick R. Brown, Jr., M.D.
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This work has been supported in part by grants-in-aid from the Alameda County Heart Association, the National Institutes of Health, and the Armour Laboratories.

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IE Role of Amino Acids in Kwashiorkor

Dear Sir:

We have reported elsewhere[1] the results of some dietary therapeutic trials on kwashiorkor (a syndrome of protein malnutrition in recently weaned infants). We had hoped that a clinical test could be evolved which might be analogous to the reticulocyte response in pernicious anemia used for the fractionation of liver extracts. Our trials have indeed shown that the infant with kwashiorkor can be used in an analogous way for testing the curative capacity of synthetic milk substitutes. The rate of rise of serum albumin and, in some recent cases (at the suggestion of R. F. A. Dean) of serum amylase, can be used as objective measures of the curative efficiency of the formula, although they have less mathematical accuracy than has the reticulocyte curve in pernicious anemia.

It is hoped that other laboratory criteria can be evolved for making the test more sensitive and accurate. The test has been called a test for "initiation of cure." It represents the change from a downward course in the illness into the beginning of recovery. Conclusions drawn from this test would not apply to what we have called "consolidation of cure," which presumably requires a prolonged use of all known essential nutrients in suitable combination and quality.

The existing test for "initiation of cure" has, however, already established certain conclusions about the nature of the curative nutrients or fractions contained in skimmed milk.

We have reported "initiation of cure" with (a) Labco "vitamin free" casein as 38 per cent of the diet with and without the addition of known vitamins, (b) a mixture of eighteen crystalline amino acids as 59.5 per cent of the diet with added vitamins including all those known to be necessary for healthy development.[1] The "initiation of cure" thus represents an extension of the depletion method for the study of amino acids.

Since our publication further tests have shown "initiation of cure" with a diet containing 16 per cent of a mixture of eleven amino acids (Rose's eight essential amino acids plus arginine, histidine, and tyrosine) and the same vitamin mixture. In four cases out of eight we obtained satisfactory "initiation of cure," without any adjunctive treatment other than the basic sulfonamide and penicillin cover which is used in all trials.

In four more cases treated with the same amino acid mixture *without* the vitamins, improvement was very much slower and less complete than we are accustomed to observe. There was less of edema, regeneration of serum protein, and slower healing of skin lesions, but the children after a week on this diet again became apathetic and anorexic. We do not regard this as satisfactory "initiation of cure."

Either these latter four cases were unusually severe or complicated or, as seems more likely, we are reaching the lower limit of amino acid formulation at which cure can be initiated by vitamin-free protein or amino acids.

We feel that the cases previously published suggest with a fair degree of certainty that the limiting nutrients in the diets which cause kwashiorkor are amino acids and that provision of these amino acids is capable of initiat-

ing cure; further, that no unknown factors are necessary for "initiation of cure" if the requisite amino acids are provided. We also feel that the additional eight cases here reported demonstrate that the limiting amino acids are among the eleven listed.

It is of considerable interest that "initiation of cure" with the casein formulations was independent of the presence of vitamins, whereas eleven amino acids alone were distinctly inferior to these same amino acids plus vitamins. It is within the realm of possibility that vitamins may in some manner permit more efficient use of the amino acids provided at marginal levels in these children. We plan to test this hypothesis experimentally.

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ACKNOWLEDGMENT

This work was supported in part by generous grants from the Williams-Waterman Fund for the Combat of Dietary Diseases, Research Corporation, New York. We wish to express our deep appreciation to Dr. R. R. Williams of the Research Corporation for his keen interest and helpful guidance in this project.

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# Diet Therapy

## FIBER IN THE DIET

By CORINNE H. ROBINSON*

PLANT FIBER is an essential constituent of the normal diet even though it has practically no nutritive value. It is not digested by the enzymes of the intestinal tract, but certain bacteria accomplish a softening and disintegration of the fibrous particles. Because of its hygroscopic effect, the proper amount of fiber gives suitable bulk and consistency to the fecal matter.

Considerable emphasis was placed some years ago on the need for roughage in the diet, but a survey of recent texts and dietary guides indicates only a cursory interest in this subject. Justifiably, it may be argued that any normal diet will provide sufficient bulk for laxation. Be that as it may, the purveyors of special dietary supplements or drugs are attaching great importance to the laxative properties of their products. The layman who has had little guidance in the planning of his diet from professionally trained persons succumbs to the claims made for these unnecessary, expensive, and sometimes dangerous products. It seems proper, therefore, briefly to review some of the essentials for the modification of the diet with respect to its fiber content.

### TERMINOLOGY

A number of terms are used to describe indigestible carbohydrate residues. Among them are "roughage," "fiber," "cellulose," "unavailable carbohydrate," and "residue." These terms are not altogether synonymous.

The publication *Composition of Foods—Raw, Processed, Prepared*[1] lists values for the fiber content of numerous foods. The values given refer to "that portion of the sample which resists solution when boiled in dilute acid and dilute alkali. It is made up largely of celluloses, hemicellulose, and lignin." These values are based, for the most part, on fresh, uncooked foods, whereas many vegetables and fruits are consumed only after cooking, which in turn may have brought about considerable disintegration. Moreover, the values for "crude fiber" do not give a quantitative expression of the nonutilized material in the gastrointestinal tract, inasmuch as the proportions of lignin, cellulose, and hemicellulose in the food may vary. Lignin is most resistant to bacterial decomposition, while the hemicelluloses are more readily attacked. A limited number of analyses of foods for their cellulose, hemicellulose, and lignin content have been reported.[2,3]

Hosoi, Alvarez, and Mann[4] reported the results of extensive studies on the amount of residue remaining in the intestine after digestion. On the basis of experiments on dogs, they found, as might be expected, that fruits gave large residues. Quite unexpectedly, unusually large residues also remained following the ingestion of milk, Swiss cheese, bread, potatoes, raw or soft cooked eggs, lard, butter, and lactose. Foods providing a minimum of residue included sucrose, dextrose, rice, farina, cottage cheese, meats, hard cooked eggs, and gelatin. When certain foods such as bread and milk, or egg in milk, were given in combination, the residue was found to be smaller than when one food alone was taken.[5]

The experiments cited above have been widely used as a basis for planning so-called

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"low-residue" diets. Unfortunately, there is no evidence which establishes that the same conditions apply in man as in the dog. There is consequently a wide divergence of opinion as to the proper foods for a "low residue" diet. Diets recommended by some are liberal in food choice and adequate in nutrition, while those described by others are greatly restricted and applicable for only short periods of time.

### INCREASING THE FIBER CONTENT OF THE DIET

Any normal diet can be so planned that it will contribute sufficient amounts of roughage to maintain laxation. The daily need for "crude fiber" has been estimated by Cowgill[6] to be about 90 to 100 mg per kilogram of body weight, or approximately 6 g per day for the adult. An example of the way in which cereals, fruits, and vegetables in any customary menu might contribute to such a fiber allowance follows:

| | | *Grams fiber*[1] |
|---|---|---|
| Orange | 1 medium | 0.9 |
| Apple | 1 medium | 1.5 |
| Cabbage | 1 serving | 1.0 |
| Potato | 1 medium | 0.4 |
| Carrots, cooked | 1 serving | 0.8 |
| Shredded wheat or | biscuit | |
| Oatmeal | ½ cup | 0.7 |
| Whole wheat bread | 2 slices | 1.0 |
| | | 6.3 |

When the fiber content of a normal diet must be increased these suggestions may be helpful.

1. Whole grain breads and cereals should be substituted for fine grain breads and cereals.
2. Three to four servings of fresh, preferably raw, fruits with skins should be eaten each day. Some stewed fruits such as prunes and dried apricots or figs are also valuable. Thus, in meal planning fruit generally replaces the customary dessert.
3. Some vegetables should be eaten raw. It is a good plan to include a salad at noon and one in the evening.

Not all persons tolerate fiber equally well. Small amounts of bran may be helpful to some, but others may find it to be especially irritating.

Milk, cheese, eggs, and meat rightly belong in the diet of increased fiber content. It is erroneous to call such foods constipating. They are, to be sure, concentrated foods without fiber, but they are essential components of a nutritionally adequate diet. It may be pointed out, in passing, that these foods are excellent sources of the B-complex vitamins which have a role in the maintenance of normal gastrointestinal tone.

It goes without saying that other factors, such as liberal fluid intake, regularity of habits, adequate rest, exercise, and relaxation also bear emphasis when the need arises.

### DECREASING THE FIBER CONTENT OF THE DIET

The bland diet described fully in an earlier paper of this series[7] may be used as a basis for planning a diet of moderately reduced fiber content. Such an allowance of food may be given in three or six meals as the situation warrants. A diet which is severely restricted in fiber is often indicated for severe diarrhea or following some surgical procedure. Whole grain cereals and breads, fruits, and vegetables are not used in such a regimen. It is also believed that milk may increase the intestinal residue; therefore, the recommendation is frequently made that milk be boiled, combined with other foods, or omitted entirely. Obviously, any diet in which these essential foods are omitted is nutritionally inadequate, and therefore should be used for only a few days unless supplemented with vitamins and minerals. The following plan may serve as a starting point for the planning of a diet which is greatly reduced in residue.

| *Suggested Meal Pattern* | *Sample Menu* |
|---|---|
| *Breakfast* | |
| Strained fruit juice | Strained orange juice |
| Refined cereal with cream and sugar | Cream of wheat with cream and sugar |
| Egg | Scrambled egg |
| White toast with butter | White toast with butter |
| Coffee | Coffee with cream, sugar |
| *Luncheon* | |
| Clear soup | Beef broth |
| Tender meat, fowl, fish, or egg | Roast beef |
| Potato, rice, macaroni, noodles | Baked potato (no skin) with butter |
| White bread with butter | Soft roll with butter |
| Plain dessert | Raspberry sherbet |
| Coffee or tea | Tea with sugar, lemon |

*Dinner*

| | |
|---|---|
| Clear soup or strained juice | Tomato juice |
| Tender meat, poultry, fish | Broiled chicken |
| Potato or substitute | Buttered rice |
| White bread with butter | Crusty white roll with butter |
| Plain dessert | Jello with Angel cake |
| Coffee or tea | Tea with sugar, cream |

*Note:* Milk may be used as a beverage when it is tolerated.

*Foods from Which to Choose*

*Beverages:*
- Coffee
- Tea
- Carbonated beverages
- Milk, as tolerated

*Breads*
- Enriched white
- Plain white rolls, soft or hard
- Saltines
- Melba toast

*Cereals*
- Refined or strained cooked
- Cornflakes, puffed rice, rice flakes
- Macaroni, rice, noodles

*Cheese*
- Cottage, cream, mild cheddar in sauces

*Eggs*—not fried

*Fats*
- Butter, margarine, cream

*Fruits*
- Strained juices only

*Meats*
- Tender beef, veal, lamb, liver
- Chicken, turkey
- Nonfatty fish

*Soups*
- Broth

*Sweets*, moderate amounts only
- Sugar and sirup
- Jelly, honey
- Hard candy, gum drops

*Desserts*
- Plain cake and cookies
- Plain gelatin
- Puddings, custard, rennet desserts
- Ice cream

*Vegetables*
- White potato without skin
- Strained juices

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# HAROLD RUSSELL SANDSTEAD (1904–1955)

CLINICAL nutrition lost one of its outstanding proponents when Harold R. Sandstead, M.D., was killed in an airplane crash November 1, 1955. He was en route to Oregon to present a lecture on nutrition problems in the Far East and to complete arrangements for nutrition surveys currently underway in Iran and Pakistan. These surveys are the beginning of widespread activities being sponsored by the Interdepartmental Committee on Nutrition for National Defense, which Dr. Sandstead was largely instrumental in establishing. He served as its first Executive Director and was in charge of the Secretariat.

Dr. Sandstead was born December 17, 1904, in Davenport, Nebraska. He graduated from Cotner College in 1927.

Upon graduation from the medical school of the University of Nebraska, he interned at the University Hospital at Omaha. After two years of practice at Schleswig, Iowa, he joined the U. S. Public Health Service and was assigned to the Marine Hospital in Cleveland. He was active in research there and later at Hines Veterans Hospital, Chicago. After an additional year of training at Johns Hopkins, he went to New York and worked on a co-operative nutrition program at Cornell Medical School sponsored by the Milbank Fund. This program involved examination of a large group of New York school children and the work was extended to a similar group at Hagerstown, Maryland, in 1941.

In 1943 Dr. Sandstead was assigned to the War Department and was stationed at the Shrivenham (England) Military Government-Civil Affairs School, where he helped prepare an estimate of the kinds and amounts of medical and sanitary supplies and equipment which would be required for an Allied invasion of Europe. During the time Dr. Sandstead served as Chief of the Public Health Branch of SHAEF, survey teams were sent into Holland under his direction to evaluate the nutritional status of the civilians.

For this work the Queen of the Netherlands in 1945 appointed Dr. Sandstead an Officer of the Orange-Nassau with Swords. He also received the Bronze Star and a citation from the U. S. Army.

Upon his return to this country he was made Chief of the Nutrition Branch of the Public Health Service. In 1948 Dr. Sandstead served as a member of the U. S. delegation to the United Nations Food and Agriculture Nutrition Conference in Montevideo, Uruguay. In 1949 he surveyed the nutritional health of the Alaskan Eskimos and in 1950, of the natives of Guam.

When the Nutrition Branch was terminated because of budgetary limitations, Dr. Sandstead was assigned to the Vanderbilt University School of Medicine, where he initiated a study of buccal-mucosal changes and their possible relation to nutrition. He had an active part in the teaching and training program of the Division of Nutrition of the Medical School.

In April 1953, at the request of the Surgeon General of the Army, he made a nutrition survey of the Korean military forces. This included thousands of Korean soldiers in various localities and in a variety of military installations. It brought Dr. Sandstead another Bronze Star with Oak Leaf Cluster. While in Korea, he saw many people with marked enlargement of the parotid glands. On his return to this country, he carried out a study which suggested that chronic bilateral asymptomatic enlargement of these glands may occur as a result of recent or remote malnutrition (AM. J. CLIN. NUTRITION 3: 198, 1955).

During the summer of 1955 Dr. Sandstead and his son Harold participated in an extensive nutrition study of the Navajo Indians in Arizona. The reports of this investigation are soon to be published and will be the first extensive study of the nutritional health of this group of Americans.

The expanding requirements for military cooperation throughout the world early indicated to Dr. Sandstead that the nutritional status of the Allied military forces would become increasingly important. With this in mind, he was largely instrumental in establishing the Interdepartmental Committee on Nutrition for National Defense. This Committee is composed of representatives from each of the departments and agencies concerned with foreign operations. The Committee chairman is Dr. Frank B. Berry, the Assistant Secretary of Defense in Charge of Health and Medical Affairs.

The Committee is guided by an advisory board of outstanding nutrition experts in the United States. Two nutrition survey teams have been organized which are currently working in Pakistan and Iran to evaluate the nutritional status of the military personnel from medical, biochemical, and dietary standpoints. With the teams are a food technologist and an agricultural economist who are attempting to evaluate the food resources of the countries.

The Interdepartmental Committee on Nutrition for National Defense, the nutrition surveys which it has initiated, and those that follow will stand as a lasting memorial to the work in which Dr. Sandstead was so intensely interested.

Dr. Sandstead's life was devoted to the field of clinical nutrition, with a continuing interest in determining practical methods for improving the nutrition of peoples throughout the world. He was extremely modest, never seeking personal credit, but always striving for the betterment of mankind as his primary goal.

In 1930, Harold Sandstead married Florence Hilton of Lincoln, Nebraska. Their two children are Martha, who is attending Syracuse University, and Harold, who is a medical student at Vanderbilt University. The happiness of their household warmed everyone who came in contact with them.

—OLAF MICKELSEN
ARNOLD E. SCHAEFER
WILLIAM J. DARBY

# Nutrition News

### Pan American Academy of General Practice

The Seventh Convention of the Pan American Academy of General Practice met at San Juan, Puerto Rico, U.S.A., from January 29 to February 5, 1956, as part of a joint convention in which the Latin American Academy of Physical Medicine and the Pan American Association of Medical Specialties also participated, with further meetings held in Willemstad, Curaçao, Netherlands West Indies (February 5–8) and in Caracas, Venezuela (February 9–11).

Among the papers read were "Some Observations on the Oral Use of a Polysorbate-8-Choline Mixture," by Leo L. Morgenstern, M.D., White Plains, N. Y., and "Gout and Gouty Arthritis," by John H. Talbott, M.D., Buffalo, N. Y.

### Calories in Intravenous Solutions

The following communication has been received from the Nutrition Research Department, Abbott Laboratories, North Chicago, Ill.

"Investigators in the field of intravenous nutrition have often incorrectly ascribed 4 calories per gram to intravenous dextrose. U.S.P. dextrose is in the form of the mono-hydrate and therefore contains only 3.4 calories per gram. This was pointed out in the paper "Some Considerations Regarding Invert Sugar and Dextrose" (*Journal of Applied Physiology* 4: 793, 1952). Fructose, on the other hand, is used in intravenous solutions as the anhydrous form, supplying 3.75 calories per gram.

"The question of the calorie value of invert sugar has also been ascribed as 4 calories per gram. Since the content of invert sugar is determined on the solids basis, this value, like that of fructose, is estimated to be 3.75 calories per gram.

"In comparisons of intravenous dextrose and intravenous fructose these differences are not generally taken into account. For instance, injection of a liter of Dextrose, U.S.P., 10%, does not supply the full sugar equivalence of Fructose, 10% or Invert Sugar, 10%. Thus, only 90 g of anhydrous dextrose (equal to 337.50 calories) is supplied in the first injection, as compared with 100 g fructose or invert sugar and 375 calories in the latter two.

"New and Non-Official Remedies, 1955, gave for the first time a value of 3.4 calories per gram for dextrose and 3.5 calories per gram for the solids of protein hydrolysate injections. Thus a 5% protein hydrolysate solution will provide 175 calories per liter and a similar solution containing in addition 5% dextrose will supply 345 calories per liter. A corresponding solution made with fructose instead of dextrose would contain by calculation 362.5 calories per liter."

# Nutrition Briefs

## CURRENT OBSERVATIONS OF CLINICAL INTEREST

ACUTE pancreatitis occurred in a healthy, athletic 18-year-old boy following the sudden ingestion of a huge amount of food (2244 cal within one hour) after a period of prolonged starvation and dehydration during which he lost 10 lb in 12 days to meet a wrestling match requirement.

W. V. McDermott, Jr., M. K. Bartlett, and P. J. Culver. *New England J. Med.* 254: 379, 1956.

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PROLONGED administration of reserpine (0.25 mg, 4 times daily) to 20 adult patients produced no consistent change in volume or concentration of gastric hydrochloric acid.

J. A. Rider. *Proc. Soc. Exper. Biol. & Med.* 90: 636, 1955.

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PATIENTS with liver disease (cirrhosis and hepatitis) had serum vitamin $B_{12}$ levels considerably higher than normal. Patients in hepatic coma had values between 30 and 40 times the normal. Vitamin $B_{12}$ metabolism is seriously altered in liver disease.

P. N. Jones and E. H. Mills. *J. Lab. & Clin. Med.* 46: 937, 1955.

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USING radioactive iron to study absorption in man, it was found that anemia *per se* does not influence iron absorption. However, in uncomplicated iron deficiency and in hemochromatosis, absorption was significantly increased.

G. Pirizio-Biroli and C. A. Finch. *Clin. Res. Proc.* 4: 51, 1956.

OLDER persons with low blood levels of vitamin A, niacin, and ascorbic acid suffer a higher mortality rate than do persons with greater amounts of these substances in the blood. No relationship was found between mortality rates and hemoglobin, caloric intake, protein, fat, or carbohydrate intake.

H. D. Chope and L. Breslow. *Am. J. Publ. Health* 46: 61, 1956.

## RECENT ADVANCES IN EXPERIMENTAL NUTRITION

DEPOSITION of glycogen in the liver is accompanied by accretion of water and potassium, but no phosphate enters the liver. These observations support the theory that the fall in serum inorganic phosphate associated with glucose administration is a measure of the peripheral utilization of glucose.

N. Nichols. *J. Clin. Investigation* 34: 1710, 1955.

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MICE in which a pituitary adrenocorticotropic tumor has been implanted were found to have an elevated body fat content although body weight was normal. The body cholesterol content was also greatly increased. This is another illustration of the differences between overweight and obesity.

J. Mayer, C. Zomzely, and J. Furth. *Science* 123: 184, 1956.

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A FAT test meal (containing radioactive $I^{131}$-labeled fat) in dogs with and without pancreatectomy or bile duct ligation revealed that bile plays a minor role and pancreatic juice a major role in fat absorption.

M. H. Wells, W. W. Shingleton, and A. P. Sanders. *Proc. Soc. Exper. Biol. & Med.* 90: 717, 1955.

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IRRADIATION of food produced a change in flavor and odor of ground beef, and a slight change in color of strawberries and powdered milk.

V. E. McGary, M. E. Shipman, and L. M. Bernstein. *J. Am. Dietet. A.* 32: 123, 1956.

# Nutritional Quotes

### New Directions in Nutrition

"It would be rash, indeed, to make predictions of what new discoveries science may bring to nutrition in the next 5 or 10 years. My concern is that we are not applying the things that are already known. But there are three directions that seem likely to me.

I think that the vitamin craze is just about over, and that new emphasis will be put on proteins and on minerals. It is not yet clear that all benefits of proteins derive simply from the amino acid components, but possibly another 5 years will clear up this important point. The idea of balance in the diet, which is an old one, will receive more and more attention.

In Food Technology there have been amazing changes in recent years and we can expect many more. Most of these provide foods in some more convenient form and this is likely to be the dominating consideration rather than good nutrition. In fact, there is a constant and continuing threat to good nutrition in many technological developments, but I find it encouraging that many food companies as well as many people are conscious of this threat. The problem lies in trying to get the information we need to answer the questions raised by each technological change. These developments in technology all cost money and the cost of food must therefore tend upwards."

—L. B. Pett, *Canad. Serv. Med. J.* 7: 198, 1956.

### Solid Food in Infant Feeding

"There is another tendency in modern infant feeding which needs to be brought under critical scrutiny. This is the practice of beginning solid food supplements at increasingly early ages. Early in the 1920's, solid food additions were made rather cautiously during the latter months of the first year. Marriott, in the second edition of his excellent book on infant nutrition published in 1935, states that the appropriate age to begin solid food additions is six months. Today, many infants are having their milk diets supplemented by solid foods as early as the second and third week of life and many more, perhaps a majority, by the beginning or middle of the second month. It is difficult to justify this practice on purely nutritional grounds. The infant's first nutritional need beyond that supplied by an adequate formula and vitamins is for iron and perhaps for some of the vitamins of the B complex, especially thiamine. Iron stores are sufficient for the first three or four months of life. Even these nutritional requirements could be met by medicinal administration.

Some maintain that the early feeding of solid food is of psychologic advantage in that the baby can be accustomed to a wide variety of foods at an early age. It seems more likely that the practice is merely the result of competitive empiricism among both physicians and parents, a trend which began many years ago. It can be expected that the pendulum will shift back a little as more exact data are accumulated concerning the optimum time for introduction of solid food into the infant's diet. Considering the infant's nutritional requirements, three months of age would seem to be a reasonable time for routinely beginning solid foods. Exceptions can be made for rapidly growing, hungry infants who are not satisfied with full bottles of the milk feeding."

—L. F. Hill. *J. Lancet* 76: 74, 1956.

### Nutrition in Stress and Infection

"There is no doubt of the importance of maintaining adequate nutrition in infections or other stress situations. The value of nutritional therapy in diverse pathologic states—for example, tuberculosis, rheumatic fever, chronic ulcerative colitis, burns, and after surgical operations—has been established beyond question. The serious defect in knowledge is lack of precise information about nutrient needs in specific diseases. The therapeutic efficacy of large doses of vitamins, given individually or in combination, has not been determined under controlled conditions."

—Grace A. Goldsmith. *New England J. Med.* 254: 167, 1956.

### Diet and Caries Control

"Recent studies have shown that the rate of oral clearance is a primary factor in the control of dental caries. Further, the composition of the saliva may be of great importance in resistance to caries. While fermentable sugars are the principal dietary contributors leading to dental caries, they are not the only dietary cause. Mineral components of the diet are assuming greater importance as our information on the subject increases. Nutritive balance, especially of the mineral elements, is essential to the dietary control of caries. Tooth maturation under favorable conditions greatly favors subsequent resistance to the disease. It appears that certain anti-cariogenic factors may be present in food, or feed. From the evidence available, it must be concluded that diet plays a major role in caries control."

—Paul H. Phillips. *J. Am. Dietet. A.* 22: 114, 1956.

# Reviews of Recent Books

**Vitamins and Hormones. Advances in Research and Applications, Vol. XIII,** edited by R. S. Harris, G. F. Marrian, and K. V. Thimann, Academic Press Inc., New York, 1955, pp. 382, $9.00.

As we said in a review of the preceding volume of this annual publication (Am. J. Clin. Nutrition 3: 432, 1955), "this is another in what has become an outstanding series of survey articles." The current issue is particularly valuable to investigators in the nutritional sciences. Among the subjects, all written by active workers, are the role of vitamins in antibody production, the physiology of the essential fatty acids, the chemotherapeutic action of vitamin $B_{12}$, and the relationship between nutrition and parasitic infection.

It would be difficult to single out any of the nine presentations for special comment, but the reviewer cannot refrain from especially praising L. B. Pett's clear and thoughtful essay on vitamin requirements of humans. The introduction, "The Illusion of Vitamin Requirements," should be required reading for everyone.

An equally outstanding review, O. Hechter's "Concerning Possible Mechanisms of Hormone Action," is a model of scientific reasoning and attractive communication.

That there is a need for surveys of this type is confirmed by the continued success of the series. It is more difficult to assess the benefits which accrue to the scientific reader. In my opinion, the benefits are great indeed. If any change is contemplated at all, it should be in the direction of encouraging speculation and interpretation, as illustrated so well in several articles in this volume. S. O. W.

**Ion Exchange and Adsorption Agents in Medicine—The Concept of Intestinal Bionomics,** by Gustav J. Martin, Little, Brown and Co., Boston-Toronto, 1955, pp. 333, $7.50.

In the first portion of this book the author deals with the fundamental physical and chemical characteristics of ion exchange materials. The explanation of variations in action of these exchanges depending upon changes in physical and chemical properties is both enlightening and interesting. The author then advances into the fields of the physiologic and therapeutic application of these substances. In these chapters the reader may find the opinions and conclusions of the author more difficult to accept. In the author's own series of 100 patients with peptic ulcer treated with anion exchange resins, less than two-thirds were benefited by the treatment. Certainly this is not a sufficiently striking "therapeutic triumph" to warrant the statement that "the anion exchange resins represent the agent of choice in the treatment of peptic ulcer." Indeed, this reviewer knows of no gastroenterologist who is employing these agents in the treatment of peptic ulcer at this time (and I allude to several whose favorable reports are included in the text.)

The section on cation exchange resins outlines the therapeutic indications for these substances, as well as results of their clinical application. Again, it is the opinion of the reviewer that these exchangers are rarely used. Although formerly widely employed in the treatment of edema, ascites, and certain abnormalities of electrolyte balance, the use of exchange resins in these conditions has been almost completely abandoned.

The next section of the book is a brief consideration of the chemistry and medical applications of nonresinous ion exchange and adsorption materials such as charcoal, kaolin, magnesium trisilicate, cellulose derivatives, etc. In addition to a discussion of their uses and limitations, the author points out the need for more adequate investigation of these widely used substances.

Finally, the author propounds his concept of intestinal bionomics. It is the author's contention "that all degenerative disease has as an important component in its etiology—the absorption from the intestine of small quantities of toxic chemicals." Since no evidence for this theory is given, no comment is needed.

The reviewer feels that the better portions of this book are concerned with the physical-chemical properties of exchange materials and their mechanisms of action. The clinical reviews may serve as a source of reference but are not likely to stimulate renewed interest in the therapeutic application of these ion exchangers. Stanley H. Lorber

**Allergy Cooking,** by Marion L. Conrad, Thomas Y. Crowell Company, New York, 1955, pp. 380, $5.00.

From a long personal experience with allergy, the author of this book has compiled more than 600 recipes including appetizers, meats, poultry, fish, sauces, vegetables, salads, fruits, desserts, and beverages. Menu and recipe combinations are planned for a basic diet adjusted to individual allergies. The basic plan includes meat, fish, or fowl; potatoes or other allowed starch; vegetables and fruits. Suggested menus and recipes are also included for the basic diet with additions of milk, eggs, and/or wheat.

The recipes are practical and are so planned that the product may be used for the entire family. The author

has shown considerable ingenuity in achieving varied and interesting dishes which require, for the most part, only those ingredients available in any food market. The methods of preparation are clearly and concisely given.

Special problems, such as eating-out at parties, restaurants, picnics and camping trips, and dietary variations for children and elderly persons, are discussed briefly but adequately. It is unfortunate that some of the nutrition information was not more carefully checked before publication. For example, on page 39, the term "powdered calcium" is used, and should have been designated as a specific calcium salt. On page 136 appears the statement that a medium-size white potato contains as much calcium as "half a tablespoon of cream cheese." While the statement is correct in itself, it is misleading in that it implies to the uninformed that cream cheese is an important source of calcium, which it is not. On page 355 the units for calcium and iron are erroneously given. Values given for thiamine, ascorbic acid, and riboflavin are those representing micrograms and milligrams, but are stated to be International Units, a designation long since obsolete. The discussion on reducing and gaining weight as presented by the author, is confusing and could well have been omitted.

The author urges each patient to use this book as a supplement to a physician's prescription. When so used, the patient will obtain many valuable suggestions for meal planning and preparation. The dietitian will find the book useful as a reference for its recipes.

C. R.

**Protein Malnutrition,** edited by J. C. Waterlow. Cambridge University Press, 1955, pp. 277, $3.50.

The title "Protein Malnutrition" may be misleading as a description of the proceedings of a conference held in 1953 and sponsored jointly by the Food and Agriculture Organization of the United States, World Health Organization, and the Josiah Macy, Jr., Foundation. The conferees could not agree on a single definition of protein malnutrition and much of the conference was concerned with kwashiorkor, which some members equated with protein malnutrition and for which no entirely agreeable definition could be made. For readers familiar with the style of the Macy conferences, this apparent lack of finality will be no surprise, for these meetings are not designed or intended to arrive at a final answer, but rather to explore a subject by free discussion among a small group of experts representing different avenues of approach. This conference (four days in Jamaica) followed the typical Macy pattern, so that anyone interested in a didactic presentation or discussion of the subject should look elsewhere.

First, the participants are listed much as the *dramatis personae* before a play. The remainder of the book also resembles a play, as it is pure dialogue. But here the resemblance becomes less exact, for the plot is rather vague, the argument often wanders far from the story line, and there is little or no dénouement. The discussion, however, usually held a point, was generally erudite, sometimes witty, and occasionally sharp.

The participants are all experts, many with extensive first-hand experience with problems concerned with protein malnutrition, kwashiorkor, and marasmus as these conditions are seen among infants and children in the West Indies, Africa, India, and Central and South America. All three conditions are undoubtedly due primarily to malnutrition. Which diagnosis will apply to a particular patient a reader may have in mind, depends upon which of the several given definitions the reader accepts or whose argument is the most convincing.

The recorded discussion takes up successively the biochemical aspects, pathology, clinical aspects, epidemiology and prevention of protein malnutrition. A summary follows each section but the last. Unfortunately, no index is included.

Some readers may well wonder why the proceedings of a conference as informal as this one should be published, but for those deeply interested in the field the book is important as an attempt to integrate concepts of disease from several quite diverse parts of the world. For those who believe they know what protein malnutrition, kwashiorkor, and marasmus are the book is a must, but in this case it should be read with caution as it will upset many preconceived ideas.

CHARLES S. DAVIDSON

# Abstracts of Current Literature

CHARLES R. SHUMAN, M.D., EDITOR

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## DIETARY MANAGEMENT OF PEPTIC ULCER

*Diet therapy remains the most important factor in the treatment of peptic ulcer, despite the constant flow of new drugs which assist in reducing hypersecretion and motility. The diet must be prepared of foods which are mechanically, thermally, and chemically nonirritating, with emphasis placed upon their acid-neutralizing capacity. A substantial protein component of the diet is necessary for the promotion of healing of the ulcer. Most of the necessary qualities for anti-ulcer activity in foods are found in milk, except for such factors as ascorbic acid and iron, with which the ulcer diet may have to be supplemented. In severe cases with intractable pain, an intragastric milk drip through a thin latex tube may represent an ideal method of treatment.*

**Continuous Intragastric Milk Drip in Treatment of Uncomplicated Gastric Ulcer.** R. Doll, A. V. Price, F. Pygott, and P. H. Sanderson. *Lancet* 1: 70, 1956.

The value of continuous intragastric milk drip in the treatment of gastric ulcers has been investigated in a carefully controlled trial covering 164 hospital in-patients. Half the group received a drip of 6 pints of milk in 24 hours and half of this group had 40 g of sodium bicarbonate added to the milk.

The proportion of ulcers which healed in a month was dentical in the two treatment groups and the average degree of healing was also similar. The patients with the milk drip gained more weight than the others.

"The impression was received that pain was relieved more rapidly with milk drip than without it; and alkalinised milk drip is considered a useful adjunct to the standard treatment in patients whose pain persists after rest in bed."—F. E. HYTTEN

*The dietary management of patients with massive hemorrhage from ulcer is a matter of dispute. Many authorities favor the feeding of a Meulengracht regimen, while an older school recommends fasting while transfusion and treatment of shock are progressing.*

**Continuous Intragastric Milk Drip in the Treatment of Upper Gastrointestinal Haemorrhage.** A. M. Dawson. *Lancet* 1: 73, 1956.

One-hundred cases of upper gastrointestinal hemorrhage were managed with an indwelling Ryle's tube, and alternate cases were treated with a continuous intragastric milk drip of 6 pints of nonalkalinized milk in 24 hours.

The two groups were closely matched for age and cause of bleeding.

There was no evidence that a milk drip prevented recurrence of massive hemorrhage.—F. E. HYTTEN

**Dietetic Treatment of Peptic Ulcer.** R. Doll, P. Friedlander, and F. Pygott. *Lancet* 1: 5, 1956.

Although the principal treatment of peptic ulcer for over a century has consisted of a diet of "bland" foods, the value of this treatment has never been scientifically demonstrated.

Sixty-four hospital in-patients were randomly divided into two groups, one of which was given the hospital "ulcer" diet and the other an "almost normal" diet. Both diets are described in detail; fried foods were omitted from both. The two groups were closely comparable before treatment in respect of symptoms, body weight, and size of ulcer.

Among patients on the "almost normal" diet, the ulcers healed more quickly and they gained weight more rapidly although symptoms disappeared more quickly on the "ulcer diet." Half the patients in each group

were given an intragastric milk drip: they had less pain than those without the milk drip.

Out-patients with radiographically proved gastric ulcer (80 patients) and with radiographically proved duodenal ulcer (50 patients) who had been treated by standard methods and were pain-free, were randomly divided into two groups. One group continued the ulcer diet and the other groups were recommended to revert to a normal diet. Both groups were given alkaline powder to take as necessary. They were seen at 3-month intervals and finally assessed at the end of 12 months. The proportions of patients in whom the ulcer was found to be healed and the proportions who were pain-free throughout were closely similar in the two treatment groups, but treatment failed in 16 per cent of the "ulcer" diet group compared to 8 per cent of the normal diet group.

The conclusion from these results is that dieting with "bland" foods does not increase the rate of healing of peptic ulcers but "these results should not be interpreted as signifying that the pathogenesis of peptic ulcer is entirely unrelated to diet. But specifically harmful or curative factors—if they exist—do not appear to have yet been adequately identified."—F. E. HYTTEN

**Complete Nutriment for the Therapy of Peptic Ulcer.** A. Winkelstein and E. Schweiger. *J. A. M. A.* 160: 1111, 1956.

A nutrient supplement was used in the clinical treatment of gastric diseases. This material when mixed with water supplied 3.9 cal/g. It is composed of 24 per cent protein, 68 per cent carbohydrate, and 8 per cent fat, as well as minerals and vitamins.

Gastric analyses in 16 patients revealed that the oral administration of 240 ml (135 g of the powder) virtually abolished free hydrochloric acid for one to two hours. Four patients received this mixture and, on alternate days, an equal amount of whole milk. Gastric aspiration indicated a transient decrease in free acid after milk (in fact, after an hour the acid was higher than was the fasting level). In this small group free acid was almost completely neutralized for one to one and one-half hours by the supplement. Continuous intragastric drip in 6 patients led to effective acid neutralization.

According to the authors, this material is easily prepared, palatable, and has excellent buffering power. It is said to be superior to milk in neutralizing properties, in prolonged effect (?), and in absence of secondary rise in free HCl.

There is a one-sentence mention that several patients (presumably with peptic ulcer) who were refractory to the conventional Sippy type of treatment, were given this mixture with promising results. Nevertheless, it remains to be shown that patients with peptic ulcer (rather than with high gastric acid analyses) will respond better to this nutriment than to existing dietary methods.—S. O. WAIFE

## KWASHIORKOR AND PROTEIN MALNUTRITION

*Since 1949 there have been extensive studies devoted to the epidemiologic, sociologic, and clinical aspects of protein malnutrition, which represents the most widespread nutritional disorder in tropical and subtropical areas. The syndrome observed in protein-deficiency states has been termed malignant malnutrition, polydeficiency disease, multiple deficiency syndrome, and, more popularly, kwashiorkor. It has been described by workers in many parts of the world, including the United States, and variations in the clinical characteristics of this disorder in different areas have emerged. These variations may represent differences in the amino acid composition of the deficient diets or the severity and duration of protein deficiency. The necessity for a broad and well-disciplined approach is clearly indicated and progress is being made under the direction of interested agencies such as the FAO and WHO.*

**Multiple Deficiency Syndromes in Infants and Children (Venezuelan Kwashiorkor).** G. Tovar-Escobar and B. L. De Majo. *Doc. Med. Geogr. Trop.* 7: 116, 1955.

**Kwashiorkor.** L. N. Went. *Doc. Med. Geogr. Trop.* 7: 139, 1955.

The word "kwashiorkor" is not much used in Latin America; most workers there prefer the term "multiple deficiency syndrome," or some variant of it. The use of more than one name to describe what is probably the same disease does not matter, provided it does not cause confusion. In the present case, however, there is confusion. Tovar-Escobar and De Majo state that "the condition observed in Venezuela is very similar but not identical to kwashiorkor. . .we have not observed the main characteristic of kwashiorkor which is the skin depigmentation." It is not the fault of the Venezuelan workers that this distinction that they make is artificial, since in the past a great deal of stress has been laid on dyspigmentation in kwashiorkor. However, most workers now agree that it is not valid to concentrate on one particular sign, such as changes in color of skin and hair, as the essential diagnostic criterion of kwashiorkor, particularly when the relation of this sign to the cause of the disease is not known. In Jamaica, for instance, we frequently diagnose kwashiorkor in a child with normal skin and hair, if enough of the other characteristic signs are present. It is, in fact, now widely accepted that "multiple deficiency syndrome" and kwashiorkor are basically the same disease which from place to place may present variations of detail, depending, no doubt, on differences in the local diet.

Once this is accepted there seems no reason why everyone should not use the name he prefers. "Kwashiorkor" has, however, certain advantages. It does not direct attention to one sign, such as edema or fatty liver, to the exclusion of others; in fact, it is noncom-

mittal and yet conjures up a fairly vivid clinical picture. As these authors point out, the term "multiple deficiency syndrome" has the disadvantage of leading to a concentration on vitamins and amino acids in treatment, which is both unnecessary and expensive. In recent years the name kwashiorkor has become more widely accepted, particularly in North America, and its status is now much the same as that of beriberi. The point made by Went is extremely important, that the original translation of the African word, which suggested that it referred to the color of the patient, is in fact wrong. The word really means "the deposed baby." There can therefore no longer be any objection to applying this name to cases who show no changes in color of hair or skin.

This paper is an excellent account of the disease as it occurs in Venezuela, and it is a useful contribution to the world literature, being the first report from that country in the English language. The average age of the cases is not stated, but they appear to be somewhat older than in many other parts of the world. The most common feature was edema, and skin lesions described as pellagrous were also frequent. There were the usual changes in the blood—moderate anemia and hypoproteinemia. It is of great interest that liver function tests showed no difference between cases of multiple deficiency syndrome and cases of simple dystrophy or marasmus. In both groups the tests were usually positive.

The treatment was based on milk; no particular benefit was observed from vitamins and amino acids. The paper includes a useful description of the dietary habits of the Venezuelan people, and a summary of the measures being taken by the government to prevent malnutrition. The authors state that the multiple deficiency syndrome is the most serious nutritional problem in Venezuela, but it is a problem of public health and not primarily one of clinical medicine.—J. C. WATERLOW

**Clinical Observations on Kwashiorkor in Calcutta.** K. L. Murkherjee and D. B. Jelliffe. *J. trop. Paediatr.* 1:61, 1955.

In the early days of work on kwashiorkor it was thought that the disease was confined to children of African stock, since it had not been reported from India or other Eastern countries, and the significance of the syndromes described under different names in Central America had not been appreciated. In the last few years this deficiency has been made good, and it is now clear that the disease affects all races and occurs in every continent, including Europe, wherever there is poverty and lack of milk.

This paper is a straightforward account of typical cases seen in Calcutta. Diarrhea appeared often to be a precipitating factor. Because of diarrhea the babies were put for long periods on diets of rice-water or other starchy paps. Such a regimen, if prolonged for months, inevitably results in malnutrition. Exactly the same sequence was described 50 years ago by Czerny in Vienna.

The Calcutta cases were selected for their severity, and most subjects had characteristic skin lesions, which are illustrated by excellent photographs. The clinical features were identical with those found in African kwashiorkor, except that hair changes were minimal. This reinforces the point (made in the previous abstract), that it is absurd to make the diagnosis of kwashiorkor depend on one single feature of uncertain etiology, such as dyspigmentation of the hair.

The authors make the important suggestion that prolonged breast feeding in numerous pregnancies, with a consequent falling off in the volume of milk, may be an important factor in the etiology of kwashiorkor. Continuous lactation for a decade may well be bad for the mother: it is doubtful, however, whether the infant could secure an equivalent amount of milk from any other source at an equal cost—and cost is of paramount importance in any consideration of kwashiorkor as a social problem.—J. C. WATERLOW

*The turnover rates of desoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are increased in the presence of repletion or depletion of protein. The amount of nuclear DNA per cell appears to be constant, so that the ratio of nitrogen to DNA will be decreased in protein malnutrition. Since RNA is associated with protein synthesis, the ratio of RNA to DNA is low in malnutrition and rises upon repletion.*

**A Pathological Study of the Effect of Low-protein Diet on Liver Cell Metabolism.** O. Bassir. *W. Afr. M. J.* 4 (new series): 78, 1955.

The stimulus for this work was the possible effect of vegetable protein diets, such as are eaten in Nigeria, on the structure and function of the liver. Adult rats were fed a protein-free diet for four days, and repleted for one day. Measurements were made of nucleic acid content and of the uptake of $P^{32}$ into nucleic acids. The results in the main confirm those of other workers (Kosterlitz, Davidson). The tracer studies suggested an increased turnover rate of both desoxyribonucleic acid (DNA) and ribonucleic acid (RNA) during the period of depletion as well as of repletion. This is attributed to catabolism on the protein-free diet and to anabolism during refeeding. No figures, however, are given of the absolute amounts of the nucleic acids, but only of their concentrations per unit weight of liver. One of the effects of the low protein diet was a great increase in liver glycogen, which appears to be firmly held, since it persists even after six hours' fasting.

The paper is illustrated by photomicrographs of the very highest quality, showing changes in morphology and distribution of mitochondria, RNA-containing particles, and glycogen.—J. C. WATERLOW

*Protein malnutrition induces hepatic changes characterized by fatty infiltration of the parenchymal cells.*

*This condition is reversible upon dietary repletion, but may progress to fibrosis and portal cirrhosis in juveniles and adults if the faulty diet is not corrected.*

**Liver Enlargement and Protein Deficiency States in Polynesians in Western Samoa, Niue, and New Zealand.** D. D. McCarthy. *New Zealand M. J.* 54: 651, 1955.

Protein malnutrition is a significant problem in Samoa and neighboring regions. Studies on the natives and the Polynesian diets reveal that symptomless liver enlargement is prevalent among children of the weaning and post-weaning ages. A similar finding among Maori children in New Zealand, where there should be no shortage of animal protein, suggests "faulty habits," because the condition appears to be corrected by age five or six.

The hepatic enlargement in kwashiorkor and allied protein deficiency states varies in different surveys and localities; but such evidence as does exist (serum protein determination, gynecomastia, etc.) strongly indicates that protein malnutrition is common in adulthood as well as in infancy and childhood.—S. O. WAIFE

*The following reports deal with involvement of the eyes and of the nervous system in widely separated areas of the world, the common denominator of which is severe protein malnutrition.*

**Xerophthalmia in the Presence of Kwashiorkor.** H. A. P. C. Oomen. *Brit. J. Nutrition* 8: 307, 1954.

The patient with xerophthalmia is usually found in the clinic or during a more or less superficial school or village inspection. He is a child, and as he comes from an environment unaccustomed to serious medical care, it is often difficult to make the parents understand the gravity of the condition and obtain their consent for his admission to hospital. The patients with xerophthalmia described in this paper also presented many signs of what is presumed to be protein malnutrition. Most were clear cases of kwashiorkor.

Of 44 Indonesian children between the ages of 7 months and 7 years, with manifestations of advanced malnutrition, 29 presented xerophthalmia and keratomalacia, mostly to a serious degree. The latter conditions were studied with special reference to background and clinical signs. As the children came from an environment where the general food situation was not bad, it appeared that the incidence of deficiencies was due to parental ignorance rather than poverty. Carotene intake appeared satisfactory, but the intakes of animal protein and vitamin A were very low. In a few cases xerophthalmia proved to be compatible with slight weight loss and normal growth, but in more than half the cases weight reduction and growth retardation were severe.

In 22 cases of xerophthalmia, liver biopsy was performed, with the following findings: massive fatty infiltration, 10; diffuse or marginal fatty infiltration, 11; fibrosis, 9. Enlargement of the liver was present in most cases. The eye affection was the reason for seeking medical advice in only three of the 29 cases. The frequent clinical findings are described; they included edema and lesions of the skin, respiratory infections, and dysentery. Two cases of tuberculosis presented the most severe liver fibrosis. The infections made it difficult to decide whether the general condition was essentially nutritional in origin, or whether malnutrition was secondary.

Xerophthalmia is a major complication of kwashiorkor and allied conditions in Indonesia. Curative as well as preventive interest should be devoted to the whole clinical picture and not to the eyes alone. None of the cases in this series appeared to show an isolated primary vitamin A deficiency.—B. SURE

**Nutritional Spinal Ataxia.** G. L. Money and A. S Smith. *W. Afr. M. J.* 4 (new series): 117, 1955.

Four cases are described. The main symptoms were blurring of vision, paresthesiae, and ataxia. Examination showed evidence of posterior column disease, without involvement of cerebellum or pyramidal tracts. There was also bitemporal pallor of the optic discs. Blood, cerebrospinal fluid, and gastric acidity were normal. The differential diagnosis is discussed, and the authors conclude that the cause is nutritional, although they are not able to specify the nature of the deficiency. In two cases a history was taken of the diet during the preceding years; this consisted mainly of starchy roots—cassava and yam—and was clearly deficient in protein and vitamins of the B complex. Similar cases have been described sporadically in other tropical countries, and among prisoners in the last war; they frequently show lesions of mucocutaneous junctions and other evidence of B-complex deficiency.

Once established the condition appears to be incurable, although the disability may be mitigated by physiotherapy. Since it leads to permanent crippling, the disease constitutes a public health problem of some importance.—J. C. WATERLOW

*Early studies on the treatment of kwashiorkor demonstrated the need for protein provided in the most soluble form. For this purpose a caseinate preparation was employed which was found to improve rapidly the clinical condition of the patients. The use of synthetic amino acids has also been shown to produce prompt improvement, illustrating that the disorder fundamentally represents amino acid depletion. The problem is essentially that of providing an inexpensive and well-tolerated protein source, such as preparations of skim milk (which may have the disadvantage of causing diarrhea) or supplemented vegetable proteins.*

**Kwashiorkor and Protein Malnutrition. A Dietary Therapeutic Trial.** J. F. Brock, J. D. L. Hansen, E. E. Howe, P. J. Pretorius, J. G. A. Davel, and R. G. Hendrickse. *Lancet* 2: 355, 1955.

It is well known that the cure of kwashiorkor can be

initiated by a diet of skimmed milk. In the trial described here, various mixtures in which some or other of the nutrients in skimmed milk were eliminated were fed to subjects with kwashiorkor in an effort to define the precise nutrients responsible for initiating the cure—"initiation" being taken to end at the point when the child has become so much improved clinically as to be demanding a mixed diet.

Tests were carried out at three centers in South Africa on a total of 135 children, varying in age from 8 to 55 months, the great majority less than 24 months. The criteria of cure were chiefly clinical but included the rise in serum albumin The diagnostic criteria, the schemes of treatment, the compositions of the formulae fed, and the results are presented in detail. Briefly, the most striking finding was that a formula consisting of "Labco vitamin-free casein," dextrose, and a salt mixture was no less effective than skimmed milk, even the skin and mucous membrane lesions which are usually attributed to vitamin deficiencies healing completely. A mixture of synthetic amino acids and known vitamins was also effective in a small series of cases, suggesting that no unidentified food factors are involved.

This is an important paper in the field and should be read in the original.—F. E. HYTTEN

**Comparison of Milk and Soya Beans in the Treatment of Kwashiorkor in Uganda.** M. D. Thompson, *Brit. M. J.* 2: 1366, 1955.

An attempt has been made to assess the relative values of milk and soya protein for the treatment of kwashiorkor in Uganda children. Milk feeds, made from skim milk powder, were given to 35 children, sometimes reinforced with calcium caseinate. A daily protein intake of 2.5 g/kg was found to be necessary, and although most children would take more than this, diarrhea was often a troublesome complication.

Feeds prepared from soya beans were given to 42 children, but had to be abandoned in 15. The primary difficulty with the soya feeds is one of administration. For example, a fluid feed of the same consistency as reconstituted skim milk, and suitable for intranasal feeding, had $2^1/_2$ times the bulk of milk feeds of equivalent protein content. When soya feeds were successful they were not significantly different from the milk feeds except in a somewhat longer time taken to overcome anorexia.

The author considers that milk remains the best treatment of the established disease. There is not enough milk available, however, for large-scale prevention, and, in fact, processed foods are not necessary for this. Soya beans and other vegetable sources of protein could be grown locally, but their use would require changes in traditional cooking and feeding habits, and education remains the first essential.—F. E. HYTTEN

*Methionine represents one of the deficient amino acids in the diet which results in kwashiorkor. Breast milk provides an adequate intake of this factor and apparently protects the infant from this condition.*

**Methionine Concentration in South African Bantu Breast Milk.** M. Anderson and A. R. P. Walker. *Brit. J. Nutrition* 9: 197, 1955.

Although going under different names, the disease commonly referred to as kwashiorkor is of world-wide distribution, affecting infants and young chi'dren fed on diets deficient in amino acids. This syndrome includes fatty infiltration, cellular necrosis, or fibrosis of the liver. Fibrosis in the liver may develop in infants at the age of 6 months and possibly even earlier while they are still getting the whole of their food from the breast. It has, therefore, been postulated that a factor or factors may be missing from, or deficient in, the breast milk during the first 6 months of lactation.

In South Africa kwashiorkor is common, although it does not affect wholly breast-fed infants. Determinations of methionine concentration in the breast milk of 29 Bantu compared with 25 local South African European mothers revealed no abnormality in this respect, mean values obtained being 29.7 mg and 26.2 mg/100 ml, respectively.—B. SURE

*The impairment of the pancreas in protein deficiency states has been demonstrated by histopathologic and functional studies. A reduction of pancreatic function may be responsible for the changes in protein and fat digestion reported in the following study.*

**Nitrogen Metabolism and Fat Absorption in Malnutrition and in Kwashiorkor.** K. Holemans and A. Lambrechts. *J. Nutrition* 56: 477, 1955.

In two previous communications the authors presented evidence of prolonged severe shortage of proteins in the diets of infants in Kwango (Belgian Congo). As this deficiency is believed to induce kwashiorkor in children, it was thought of interest to study the nitrogen as well as fat metabolism in such children with general malnutrition and kwashiorkor and living in the same region.

Forty-four nitrogen and fat balance experiments have been performed in African children living for a long time on protein-deficient diets and suffering from severe malnutrition or kwashiorkor. As a rule, positive nitrogen balances were obtained, showing a retention proportional to the intake (about 50 per cent). Nitrogen was best retained on about 450 mg/kg of body weight per day. Even under experimental conditions the minimum requirements seem to be maintained at the normal level of about 150 mg/kg per day.

The total fecal nitrogen averaged 21 per cent of the intake, which means a nitrogen absorption of 79 per cent, a lower value than normal. The metabolic fecal nitrogen, however, gave a normal value of 30 mg/kg of body weight per day. The nitrogen retention was as good for vegetable proteins as for animal proteins.

The fat absorption (80 per cent) was lower than that in normal children (95 per cent).

Reasons are given for thinking that only digestion is impaired in kwashiorkor and that intestinal absorption is normal.—B. SURE

**The Adrenal X-zone in Kwashiorkor.** H. B. Stoner, J. N. P. Davies, H. J. Whiteley, and J. L. Emery. *Brit. M. J.* 1: 1260, 1955.

It was reported by Gillman and Gillman in 1951 that the fetal X-zone of the adrenal gland persists in African infants dying of kwashiorkor. The adrenal glands of 7 African children dying from kwashiorkor were compared to those from 19 African children dying from other causes and with a larger series of English children. No evidence of the persistance of the X-zone was found in these cases of kwashiorkor and, so far as could be determined, the rate of involution of the fetal X-zone after birth was the same in all series.—F. E. HYTTEN

*Nitrogen retention in the presence of malnutrition occurs even at low levels of protein feeding. However, the utilization of protein for tissue anabolism requires an adequate caloric intake to prevent the excessive expenditure of absorbed protein for purposes of energy formation.*

**The Relation of Nitrogen Retention to Nitrogen Intake in Adults with Post-traumatic Malnutrition.** B. T. Forsyth, M. E. Shipman, and I. C. Plough. *J. Clin. Investigation* 34: 1653, 1955.

The important problem of the relation of nitrogen intake to nitrogen retention is again explored, but in a little different manner. Patients recovering from severe trauma were studied. Although undernourished in terms of weight, their nitrogen balances were positive at the beginning of the experimental regime. All patients were receiving adequate calories and the nitrogen retention was measured at various levels of nitrogen intake after a period of stabilization on a given diet. Utilizing extensive statistical analysis of their data, the authors concluded that nitrogen retention is directly related to nitrogen intake in malnourished individuals on adequate caloric intake, and not related to the degree of malnutrition (underweight) or to the intake of nonprotein calories.

This work points up the fact that the body will utilize large amounts of protein for anabolism if the caloric needs are provided. However, from other work it would seem that if the caloric needs are not met, any protein administered will be utilized for energy, not nitrogen storage. The authors' figures do not substantiate the claim of others that mere underweight will increase the nitrogen retention on a given diet. Apparently one must increase the protein intake to increase the nitrogen retention. This is an important concept.—J. F. MUELLER

## ALCOHOL AND NUTRITION

*Alcohol is an important dietary factor because of the frequency of its use and because it is a high energy source which may displace other nutrients. In small doses it may be used to stimulate appetite, to afford vasodilation, or to provide added calories in intravenous feeding programs. However, in alcoholism, an adequate diet is rarely consumed, so that conditioned deficiencies of vitamins and protein, with subsequent inanition and liver damage, will ensue. This has led to the hypothesis, based on animal experimentation, that nutritional deficiency may lead to alcoholism. In addition, therapeutic vitamin regimens have been widely recommended in the management of this condition. The following review is rightfully critical of these studies.*

**Nutrition and Alcoholism—A Review.** O. Mickelsen. *J. Am. Dietet. A.* 31: 570, 1955.

In this review the author comments critically on some of the studies in which it has been reported that voluntary consumption of ethyl alcohol has increased vitamin deficiencies in animals and in man. In reports reviewed from three different laboratories, rats were found to increase their alcohol consumption after a deficiency of a variety of vitamins. In some instances this consumption was reduced on addition of the missing nutrient and in others re-feeding had no effect. In the studies herein reviewed, thiamine, Factor N, vitamin B complex, riboflavin, pantothenic acid and pyridoxine deprivation were each found to result in increased alcohol consumption.

The author reviews reports from five laboratories concerning the effectiveness of high vitamin capsules in combatting chronic alcoholism in man. These preparations contained 3.3 mg thiamine, 2.67 mg riboflavin, 10 mg nicotinamide, 10 mg calcium pantothenate, 3.3 mg pyridoxine, 0.05 mg biotin, 1.1 mg folic acid, 11 mg para-aminobenzoic acid, 53 mg inositol, 53 mg choline, 5 $\mu$g vitamin $B_{12}$, 6667 IU vitamin A, 33.3 mg ascorbic acid, 6.67 mg alpha-tocopherol, and 333 IU viosterol, and as many as nine capsules were given daily for varying periods. Medication in one laboratory lasted for two months; in another as long as 18 months. Investigators from two of the laboratories were enthusiastic about the improvement of the chronic alcoholics' ability to abstain from drinking for long periods. Two laboratories reported distinctly negative results, and in one laboratory variable responses were reported.

Dr. Mickelsen questions the applicability of rat studies to an understanding of the nutritional basis of human alcoholism since the alcohol consumption of the rat is not compulsive—it can be terminated promptly when the animal is given an additional choice, such as saccharine or sucrose; and in none of the rat studies have inebriety or high blood alcohol peaks been demonstrated.

The author's review is not intended to imply that nutrition plays *no* role in alcoholism since it is desirable in rehabilitation to correct dietary deficiencies which are apt to have occurred over a considerable time. He concludes: "The few reports that describe the effect of vitamin supplementation on the drinking habits of persons addicted to alcohol indicate that the vitamins have little, if any, influence thereon. At best vitamin

supplementation may produce an increased sense of well-being in such patients."

In addition, the author points out that there is considerable evidence from an epidemiologic standpoint which argues against nutrient deficiency in the causation of alcoholism, e.g., (1) endemic beriberi, pellagra, or scurvy are not known to result in alcoholism; (2) even though men eat better diets than women, there is a much higher incidence of alcoholism in men than in women; (3) nutritional requirements are increased in women during pregnancy and lactation without a predilection for alcohol; and (4) alcoholism has been increasing during a period when nutritional deficiencies among alcoholics and the general populations have been decreasing.—J. M. SMITH

*The consumption of alcohol and its nutritional and social significance vary widely in different parts of the world.*

**Alcohol and its Nutritional Significance. Distribution of Alcohol Consumption and of Calories Derived from Alcohol in Various Selected Populations.** E. M. Jellinek. *Proc. Brit. Nutrition Soc.* 14(2): 93, 1955.

In the United States of America in 1950 the average daily consumption of ethyl alcohol was 0.53 oz per day, which contributed 88.5 calories per head. For this country it may be said that for nearly 54 per cent of the population ethyl alcohol is not a source of calories and for the great majority of actual consumers its contribution to total calories is negligible. In a fraction of the population the calories from alcohol are appreciable and in a still smaller fraction the contribution made by alcohol is so high that it constitutes a dangerous interference with nutrition.

In Italy, males account for 75 per cent of the total alcohol consumption and females for 25 per cent of it. Within the male group, 10 per cent account for 30 per cent of the actual male consumption. The average intake for 10 per cent is 227 grams per day, which provides 1612 calories. There is thus a very uneven distribution of the calories derived from alcohol.

In Chile, the average consumption rate is stated as 9.7 liters absolute alcohol per year, but in Chile the women do not drink. Thus this rate per head must be adjusted to the adult male population and should be 27.7 liters, which is about half what it is for males in France. Also, in Chile there is a consumption of distilled spirits, which is insignificant in Italy, where, too, the beer consumption is almost negligible.—B. SURE

**Some Traditional Alcoholic Beverages and their Importance in Indigenous African Communities.** B. S. Platt. *Proc. Brit. Nutrition Soc.* 14: 115, 1955.

Fermented honey drinks may have been the earliest alcoholic beverages known to man. Another hypothesis of the origin of alcoholic liquors is that they were first encountered when wild fruits were stored in clay-lined holes in the ground. If beer was not in fact originally brewed by man in Africa, some alcoholic fermentations were developed on that continent. Evidence exists that between 6000 and 5000 B.C. the Fayum folk, a late Stone Age people living in the Nile valley, cultivated barley of a kind similar to that still grown in Egypt. Although the earliest history of alcoholic fermentation is not known, it does seem likely that in Africa it is a process of considerable antiquity.

There are five main groups of African alcoholic beverages: fermented honey water; fermented fruits and juices; fermented sap from various species of palm and a bamboo; drinks made from milk; and the beers. All of these have more or less familiar equivalents in mead, cider, fermented birch sap, fermented mare's milk (koumiss) and old-fashioned ales. The commonest alcoholic beverage in Africa is a kind of beer. Various materials—sorghum, maize, millets, cassava flour, with additions of cereals, and plantains are used in the preparation of these beers.

The social aspects of the consumption of alcohol are f no less interest in Africa than in this country. Men drink because they love to get drunk. The women, although much more temperate, also get drunk sometimes. Socially and ritually, to the Nandi tribe in Africa, for example, their beer (maiyek) is important. "The European who sees a Nandi continually get drunk, although he is at the same time short of food, does not realize that beer is a social necessity and not merely an enjoyment. If a Nandi cannot from time to time give a beer party, even a small party, he will lose social standing. He will be, unofficially but none the less effectively pushed out of his rightful place in the social life of the *koret* (parish)."—B. SURE

*The high energy release associated with the metabolism of alcohol is instrumental in producing a reduction in the tissue content of vitamins and coenzymes. The low intake of vitamin- and protein-containing foods during periods of excessive alcohol consumption is also an important factor in producing deficiency states and liver damage.*

**Vitamin Deficiencies in Alcoholism.** H. M. Sinclair. *Proc. Brit. Nutrition Soc.* 14: 107, 1955.

Alcohol mobilizes vitamin A from liver stores, but does not improve the final rod threshold of the dark-adapted eye. Alcohol appears to have a direct effect in decreasing food consumption. Chronic alcoholism enhances this direct effect in various ways and can lead to nutritional deficiency.

Laennec's cirrhosis in chronic alcoholism is caused by dietary deficiency of lipotropic substances. The mechanism whereby alcohol increases the requirement of methyl-group donors is unknown. Alcholic psychoses have not been proved to be caused by nutritional deficiency, but acute deficiency of thiamine can cause Wernicke's encephalopathy. Alcoholic polyneuropathy appears to be closely related to the function of thiamine but is not necessarily caused by its dietary deficiency. Decreased phosphorylation or blocking of the catalytic action of lipoic acid might play a part.—B. SURE

**Disturbances of Carbohydrate Metabolism Caused by Barbiturates and Alcohol.** R. A. Hunter, W. H. H. Merivale, and A. J. Smith, *Lancet* 2: 1353, 1955.

Barbiturates and some other sedative drugs are well known to interfere with carbohydrate metabolism.

Glucose tolerance tests and pyruvate metabolism tests were carried out on sixteen patients receiving barbiturates either as treatment or because of addiction, and on seven alcoholics. Both groups showed a prolonged hyperglycemic response to the glucose tolerance test, and an inability to oxidize pyruvate at the normal rate. When vitamin B was given, even with the same level of barbiturate intake, a very marked improvement was seen in the response to glucose; pyruvate oxidation was restored to normal. Symptoms following the withdrawal of barbiturates were much less severe when carbohydrate metabolism had been improved by vitamin B (which vitamin B is not stated), and it is suggested that the same effect may occur in alcoholics.

"The resemblance between chronic barbiturate intoxication and chronic alcoholism, and the almost identical withdrawal syndromes, may therefore be caused by similar biochemical disturbances."—F. E. HYTTEN

*Alcohol is absorbed from the stomach as well as the small intestine, and metabolized in liver and other tissues through the action of a dehydrogenase which prepares it for utilization through acetaldehyde to the 2 carbon acetate level. These relationships, together with the important pharmacological effects of alcohol, are discussed in the following three papers.*

**The Metabolism of Alcohol.** W. W. Westerfeld. *Texas Rep. Biol. Med.* 13: 559, 1955.

In this good review of alcohol metabolism, the author stresses the presently poorly understood aspects of the subject. After alcohol ingestion the blood acetaldehyde is elevated beyond what one would expect from chemical transformation alone. Physiologically, acetaldehyde and alcohol are quite different substances, and the problems of alcohol really involve both. Whatever enzyme(s) is primarily responsible for acetaldehyde metabolism *in vivo* is not only very active in the liver but is inhibited by Antabuse, and is dependent upon an unidentified dietary factor.

Blood alcohol disappears along a straight line progression, while most substances disappear metabolically in an exponential fashion. A possible explanation is presented: its features are (a) the maximum rate of alcohol metabolism is limited by the amount of alcohol dehydrogenase present; (b) the rate of metabolism at any given time is determined by the amount of coupling substrates (such as pyruvate) present.—S. O. WAIFE

**Some Pharmacological Actions of Alcohol.** M. Wentherall. *Proc. Brit. Nutrition Soc.* 14:103, 1955.

The contribution which alcohol may make to a man's nutrition varies considerably. Alcohol is not an essential dietary constituent, but it is commonly consumed, and unlike most foods it has notable subjective and objective effects in quantities which contribute trivially to the total daily calories. Moderate drinkers are much commoner than those who consume to excess and it will be interesting to consider the effects of small doses of alcohol on healthy subjects.

When alcohol is taken by mouth, it is absorbed rapidly from the stomach, especially if the stomach is empty, and it enters the blood stream and thence is widely distributed in the body. Some 95 to 98 per cent is removed by oxidation in the liver and elsewhere, and the rest is excreted unchanged in the urine and by exhalation.

When alcohol has been absorbed, its main effects are in the central nervous system. Alcohol stimulates salivation and gastric secretion, and the stimulation of the oropharyngeal region by highly alcoholic liquids, such as brandy, probably underlies some of the therapeutic use of this substance as an analeptic. Alcohol dilates blood vessels and promotes diuresis. In large doses alcohol interferes with most functions of the central nervous system, and death can occur acutely from respiratory failure. The disastrous effects associated with heavy drinking—addiction, cirrhosis of the liver, delirium tremens, for instance, are well known.

The best statistical data on the influence of alcohol on longevity are those of Pearl (*Brit. M. J.* 1: 1948, 1924) who found that the greatest expectation of life occurred in occasional and moderate drinkers, that abstainers on the whole lived slightly less, and that heavy drinkers lived substantially less long.—B. SURE

**Effects of Alcohol on Gastric Mucosa.** A. Wynn Williams. *Brit. M. J.* 1: 256, 1956.

There is no agreement about the effect of alcohol on the stomach and the "characteristic" atrophic gastritis of spirit drinkers is by no means the rule.

Gastric mucosa from alcoholics was examined in 16 by biopsy, in 3 after partial gastrectomy, and in 6 at necropsy. Some clinical details are given.

In the 16 biopsies appearances were normal in 7, showed evidence of chronic nonspecific inflammation in 5, and chronic atrophic gastritis in 4. Of the 3 gastrectomy specimens, one was normal and 2 showed evidence of chronic gastritis. Of the six stomachs removed at necropsy, one was normal and the remainder showed hemorrhagic erosions; one of these also was chronically inflamed.

In animal experiments guinea-pigs were given 5 to 10 ml of alcohol in concentrations of from 10 to 60 per cent (including pure whisky and gin) by stomach tube. Lesions were only seen with concentrations of alcohol exceeding 40 per cent. After half an hour the mucosa was hyperemic with surface desquamation; in one hour there were necrotic foci. After two hours there were often hemorrhagic foci and frank ulcers. Fasting intensified the effect.

In 8 guinea-pigs with experimental gastric ulcers, 4 ml of 60 per cent alcohol daily did not delay healing in 4

and only slightly delayed it in 2. In the remaining 2 the ulcer had become more extensive.

Although it is clear from these findings that there is no simple relationship between alcohol and gastric pathology "it would seem prudent to continue the current practice of avoiding strong alcoholic drinks in patients with peptic ulcer."—F. E. HYTTEN

*Alcohol used for caloric supplementation of intravenous alimentation regimens appears to have merit under certain conditions of nutritional inadequacy. However, it is questionable whether this agent, which may be hepatotoxic, should be employed, as it was in the following study, in patients with hepatic disease and jaundice.*

**Alcohol in Intravenous Feeding.** A. W. Wilkinson, *Proc. Brit. Nutrition Soc.* 14: 124, 1955.

Alcohol infusions have been used in widely different circumstances. A large number of infusions have been reported to have been employed in vain attempts to maintain positive nitrogen balance during the immediate postoperative period, and in many of these the low nonprotein fraction of the total calories made failure inevitable. Infusions have also been given without apparent advantage simply to supply calories during the first day or two after operation.

The author of this study reserved alcohol infusions mainly for patients who were in advanced states of malnutrition and who could not be fed by mouth or jejunostomy. For example, in order to provide supplementary protein and calories, four patients with hepatic disease and jaundice who were so nauseated as to be unable to consume food received up to 2 liters of 6 per cent alcohol and amino acids daily for 4 or 5 days. Some benefit seems to be derived in the initial stages of treatment by a few patients with advanced malnutrition, but direct evidence of nutritional improvement has not been obtained.

Alcohol should not be administered to patients with recent head injuries or with intracranial disease and should not be used in coma associated with raised intracranial pressure. Better results may be obtained by the combination of 10 per cent fructose with alcohol and amino acids.—B. SURE

## MILK AND LACTATION

*The ability of the lactating female to produce breast milk is under the control of various influences including hormonal, metabolic, nutritional, and psychological factors. The stimulus of breast feeding and the nursing process probably represents one of the most important conditions necessary for maintaining the production of milk. Although adequate protein, calcium, ascorbic acid, and caloric intakes are desirable and even necessary for the maintenance of maternal health, it is possible to maintain breast feeding in the presence of a suboptimal supply of these dietary elements.*

**Clinical and Chemical Studies in Human Lactation. VIII. Relationship of the Age, Physique and Nutritional Status of the Mother to the Yield and Composition of Her Milk.** F. E. Hytten. *Brit. M. J.* 2: 844, 1954.

The relationships listed in the title were studied in 155 primiparae. A 24-hour sample of 7th day milk was analyzed in each case. The percentage yielding 450 ml or more fell from 55 in the age group 16–19 years, to 19 in those aged 28 or over. There was also a negative relationship with net weight change (difference between post-natal weight and weight at or before the 14th week of pregnancy), those gaining more weight tending to produce less milk. Age and net weight change were not related to milk composition (major constituents). The yield and fat content tended to be higher among tall women and those assessed ante-natally as being in "excellent" or "very good" health, but the trends were inconsistent and did not attain statistical significance. Fifty-five patients had participated in a diet survey during the 7th month of pregnancy. No relationship was established between milk yield and composition and the energy value and quality of the pregnancy diet. The discussion summarizes briefly the conclusions reached in the series of reports of which this is the latest. "The final papers in this series will deal, not with the basic ability to lactate, but with the way this ability is used to maintain breast feeding."—F. E. HYTTEN

**Synthetic Activity of a Single Epithelial Cell of the Lactating Goat Udder.** K. C. Richardson and S. J. Folley, *Nature* 174: 828, 1954.

By calculating the total area of the secretory epithelium in the half-udder of a goat, and by determining histologically the average cross-sectional area of the secretory cells, the number of cells in the gland was computed; the yield and composition of milk from the whole gland was known.

It is estimated that each cell has a mean milk output of $23 \times 10^{-11}$ ml hourly. It synthesizes $2.6 \times 10^{-9}$ g per second of lactose, $2.5 \times 10^{-9}$ g. per second of fat, and $1.5 \times 10^{-9}$ mg per second of casein.

The number of molecules which each cell synthesizes per second was calculated as 4.5 million and 4.1 million for lactose and fat, respectively.—F. E. HYTTEN

*An interesting method for testing artificial milks which will produce an acid reaction in the intestinal tract similar to that produced by whole milk in animals is reported below.*

**The Rat as a Test Animal in Evaluating Artificial Human Milk for Infants.** P. Roine, H. Gyllenberg, M. Rossander, and R. Vuokila. *Nature* 174: 519, 1954.

Although rats do not grow satisfactorily on a diet of either cow's milk or human milk, these animals were used in feeding experiments with wholly milk diets. An attempt was made to modify cow's milk in such a way that the pH of the feces—alkaline on a diet of cow's milk—became acid as they are on a diet of human

milk. The response of the fecal pH was the sole criterion of the similarity of the test mixture to human milk. Cow's milk could be modified to produce acid feces by reducing the calcium content with cation exchangers and adding lactose.—F. E. HYTTEN

*The suitability of milk as a complete food over a period of one month was tested in adult subjects.*

**Fat Utilization in Adults on a Diet of Cow's Milk.** R. Hecker and W. H. H. Andrews. *Brit. M. J.* 1: 1131, 1954.

Two adults lived for one month on a diet consisting wholly of cow's milk. General health was unaffected and body weight was maintained.

A record of fat absorption and excretion was taken over three days of the 4th week when one subject drank 12 pints daily and the other 10 pints. Fat utilization was about 94 per cent, and about three-quarters of the excreted fat appeared as soap.—F. E. HYTTEN

## VITAMIN C: INTAKE, SERUM LEVELS, ACTIONS

*The amount of ascorbic acid recommended for daily dietary intake by the National Research Council is capable of maintaining tissue and plasma levels of approximately 1.0 mg per 100 ml without excessive urinary loss. Nevertheless, at intakes considerably below those recommended, with plasma and buffy coat ascorbic acid levels near zero, scurvy has not been observed and tissue healing progresses normally. The development of changes characteristic of vitamin C deficiency probably depends upon concomitant severe stress or disease, together with a low intake, or prolonged dietary inadequacy with or without increased requirements. The following studies provide correlations between intake, biochemical levels, and urinary excretion.*

**Ascorbic Acid Utilization by Women. Response of Serum Level and Night Urinary Excretion to Increasing Levels of Intake.** M. Potgieter, E. H. Morse, and G. R Walker. *J. Nutrition* 55: 217, 1955.

Twenty women, patients at a state training school and hospital, served as subjects during the winter and spring of 1952–1953. All were in good physical health and were co-operative throughout the study. They ranged in age from 27 to 63, with only two over 40 years of age.

Two groups of women (10 experimental subjects and 10 controls) were studied regarding their response to various levels of ascorbic acid intake. The experimental subjects, after a two-month period without vitamin supplementation, received 25, 50, and 100 mg per day, each for one month, while on a diet restricted in ascorbic acid (citrus fruits and tomatoes omitted) which provided 45 mg per day. The control subjects were on the same diet, without supplementation.

The average serum ascorbic acid level for the 20 subjects fell from 0.97 to 0.42 mg per 100 ml during the two-month period on the restricted ascorbic acid intake. The maximum average serum level of 1.49 mg/100 ml was reached in the experimental subjects following the month on the 50-mg daily supplement. The average serum ascorbic acid level of the control group dropped to 0.13 mg/100 ml at the end of the five months on the restricted diet.

The average value for total ascorbic acid in the 8-hour night urine increased very slightly in the experimental subjects after the 25-mg and the 50-mg daily vitamin supplementation, but did not rise above the average value of 5 mg per subject until following the month on the 100-mg daily supplement, when it increased to an average of 30 mg. The excretion level of the control group remained at about 2 mg throughout the study.—B. SURE

**Ascorbic Acid Utilization by Women. Response of Blood Serum and White Blood Cells to Increasing Levels of Intake.** E. B. Morse, M. Potgieter, and G. R. Walker. *J. Nutrition* 58: 291, 1956.

In the previous study the authors reported the response of the ascorbic acid levels of blood serum and of night urinary excretion to increasing levels of intake of the vitamin by 20 women. The present study concerns the relationship between the ascorbic acid level in the blood serum and that in the white blood cells of a second group of women on the same graded levels of ascorbic acid supplementation as in the previous study.

The average blood serum ascorbic acid level in 19 women subjects fell from 0.97 mg to 0.47 mg per 100 ml of serum during a period of 6 weeks on a diet containing an average of 33 mg of ascorbic acid per day. The average serum level increased to 0.74 mg following 5 weeks on an intake of 58 mg, to 1.47 mg following 5 weeks on an intake of 83 mg, and to 1.69 mg following an equal period on 133 mg.

Fluctuations in white blood cell levels were consistent with those in the serum, though somewhat less marked. During the period on the restricted intake, the average white blood cell level for the subjects fell from 29.94 mg to 19.55 mg ascorbic acid per 100 g of white cells. Following the first two periods of supplementation, the white cell level rose to 26.67 mg and 34.55 mg, respectively. There was no further increase in white cell ascorbic acid level as a result of increasing the intake to 133 mg per day.

Statistical analysis of the data indicates that, with intakes between 33 and 83 mg per day, under the conditions of the present study, the average serum level was a reasonably good indicator of the average ascorbic acid content of the white cells.—B. SURE

**Comparison between Plasma Values and Results of the Saturation Test at Various Levels of Ascorbic Acid Intake.** J. Sigurjonsson. *Intern. Ztschr. f. Vitaminforsch.* 25: 186, 1954.

Of the various methods devised to evaluate the nutriture of individuals and populations with respect to vitamin C, all have their limitations. Most are of

slight value in establishing a diagnosis of ascorbic acid deficiency or latent scurvy; but their application in group studies may uncover useful evidence on the status of ascorbic acid metabolism and the adequacy of intake of the vitamin. The investigation reported here deals with plasma ascorbic acid determinations and oral ascorbic acid tolerance studies in students (aged 16–22) at a boarding school in Iceland.

There was a clear connection between plasma levels and vitamin C intake. The daily intake of the vitamin was estimated at about 40–50 mg in the autumn, 25–30 mg in winter, and 20–23 mg in spring—values which agreed well with the average values for the whole population of Iceland. At these intakes, plasma ascorbic acid values were found to be 0.57 mg in the autumn, 0.31 mg in winter, 0.16 mg in spring, and 0.11 per 100 ml in summer (June).

A simplified ascorbic acid saturation test was carried out, using a slightly smaller loading dose, i.e., 10 mg/kg body weight. Plasma and urinary ascorbic acid were determined on the first day of the study. Then, after administration of the test dose, urines were collected at 4 hours and again after 3 hours, pooled, and assayed for ascorbic acid. The same 3-hour test was repeated daily until saturation was indicated.

The results of the loading test are not easily evaluated in terms of either intake or plasma values. In the autumn, saturation occurred after two days' loading, but at other seasons some days longer were required to produce saturation. The test did discriminate between ascorbic acid intakes of 40–50 mg and of 20–30 mg, but did not reflect the smaller difference between the winter intake (25–30 mg) and the spring intake (20–23 mg).

The author concludes that plasma ascorbic acid level is a more sensitive and reliable indicator of a population's dietary intake of vitamin C than is the saturation test, since the amount of the test dose stored up by the unsaturated body tissues bears no clear relationship to the apparent retention.—C.-J. HOWELL

*The conversion of dehydroascorbic acid to ascorbic acid is dependent upon glutathione and other sulfhydryl compounds through facilitation of oxidized phosphopyridine nucleotides. Ascorbic acid, through reversible oxidative reactions, may be involved in important hydrogen transfer systems and regulation of oxidation-reduction potentials in certain tissues.*

**Relationship Between Glutathione and Ascorbic Acid in Adrenocortical Function.** W. M. Booker, J. R. Tureman, F. M. Dacosta, J. Poulson, and S. Q. Mitchell. *Am. J. Physiol.* 181: 371, 1955.

These experiments have demonstrated that cortisone prevents the decrease in adrenal ascorbic acid caused by stress. However, adrenal cholesterol is unchanged under similar experimental conditions. When the vitamin C content of the whole body was studied, it was observed that there was no difference between stressed mice and their unstressed controls. This last statement holds for both normal and adrenalectomized animals. Survival is prolonged by glutathione in both normal and adrenalectomized mice.—M. J. OPPENHEIMER

*The effect of ascorbic acid upon gastric secretion in humans is negligible. There is little information available concerning gastric secretory activity in scurvy. Further studies of the type reported below may be of interest in other species.*

**Effects of Ascorbic Acid on Gastric Secretion in Guinea Pigs.** A. W. Breidenbach and F. E. Ray. *Am. J. Physiol.* 180: 637, 1955.

Gastrocutaneous fistulae were prepared in guinea pigs. Some of the pigs were prescorbutic and others were not. Gastric juice was collected from both series. It was observed that ascorbic acid injections increased the normality and the ascorbic acid concentration. Although histamine increased the normality and the rate of secretion, it did not increase ascorbic acid secretion. In prescorbutic animals, the normality of gastric juice was less than that of nonscorbutic controls, provided histamine was not used. If a histamine stimulus were used, differences did not appear.—M. J. OPPENHEIMER

*The only significant dietary sources of vitamin C are vegetables, liver, and fruits. The analysis of the fruit reported below reveals the highest content yet described.*

**Ascorbic Acid Content of Baobab fruit.** W. R. Carr. *Nature* 176: 1273, 1955.

The Baobab tree (*Adansodia digitata L.*) is widespread in parts of Southern Rhodesia and its fruit is commonly eaten by the local population.

Samples of the fruit were collected and the pulp analyzed for ascorbic acid. The mean content was 306 mg/100 g (range 175–445); it seemed to be largely present in the reduced form.

The fruit therefore, is an important source of vitamin C in a region where other fresh fruits and vegetables are scarce.—F. E. HYTTEN

## ITEMS OF GENERAL INTEREST

**The Specter of Malnutrition in Chronic Illness.** J. I. Goodman and W. Dowdell. *Ann. Int. Med.* 43: 1241, 1955.

It is common knowledge that nutritional disorders reach their peak among patients with chronic diseases. In this paper various aspects of this large problem are discussed. Of 431 patients in a county nursing home, 43 per cent had "nutritional disturbances." A group of 138 cases (32 per cent of the total) were selected for further study. The age distribution paralleled that of the Home's population, suggesting no special predilection of malnutrition for the aged. The average weight loss in this series was 40 pounds. Satisfactory descriptive terms do not exist, but the records indicate "poorly nourished," "thin," "chronically ill," "wasted," "senile," etc.

Hepatomegaly was present in 89 of the 138 cases. This enlargement on percussion is probably due to fatty infiltration. Dental defects were frequent; pallor, weakness, and decubitus ulcers were present in 37 cases each. Other common findings were muscle atrophy, and mucosal changes such as glossitis. Psychiatric aberrations, edema, and diarrhea were less frequent. (It must be remembered that this is a small selected group without adequate study of noninstitutionalized persons of comparable age and not suffering with long-term illness.) Those conditions in which malnutrition was most prevalent were cerebral dementia, rheumatoid arthritis, carcinoma, and congestive heart failure. The principal causes of malnutrition were found to be "poor eating habits of long standing," psychiatric disturbances, anorexia, and solitude.

The average red blood cell count was just under 4 million per μl, and hemoglobin 11.6 g per 100 ml. The anemia was normochromic. Serum protein values, where determined, were within the normal range.

A high calorie (4350) diet with multiple feedings and nutritional supplements was used and a favorable response obtained in over half. Unfortunately, the details are too meager to permit a proper evaluation of the regimen. Thiamine chloride, methyltestosterone with estrogens, and thyroid extract seemed to have some adjuvant value. Other hormones, vitamin and liver preparations, stomachics, and even tube feedings were probably of no value.

In the reviewer's opinion the subject is too vast for superficial discussion, and it is hoped that specific aspects of the problem can be more fully presented.—S. O. WAIFE

**Oxford Child Health Survey. Effect of Childish Ailments on Skeletal Development.** D. Hewitt, C. K. Westropp, and R. M. Acheson. *Brit. J. Prev. & Soc. Med.* 9: 179, 1955.

The primary object of the Oxford Child Health Survey is the study of the effects of environment on physical development. The population and basic methods of collecting the data have been described in other papers. In this study, the effect of illnesses on skeletal growth was examined in 327 boys and 323 girls between one and five years old. Growth was estimated from differences in standing height and skeletal maturity from X-ray films of hands and knees. The statistical treatment of the data is presented in detail.

Briefly, it was found that children who had an illness during a given year were shorter than children who had been healthy. The mean difference was a little less than $^1/_4$", which is small compared to natural variations in height. The authors feel that this small stunting is nevertheless important, because whereas growth may temporarily cease, maturation does not, and the stunting may therefore be permanent. The effect can be seen in X-ray films where an illness may be marked by a line of condensed bone. No attempt has been made in this paper to relate differences in growth to differences in social environment where other circumstances such as poor diet may accompany an increased sickness rate.—F. E. HYTTEN

**Paradoxical Hyponatremia Associated with Heart Failure and Cirrhosis of the Liver.** P. J. Talso, N. Spafford, G. Ferenzi, and H. D. Jackson. *Metabolism* 5: 58, 1956.

A reduction of serum sodium concentration without depletion of sodium stores has been reported in certain cases of heart failure and hepatic cirrhosis. In the present study, exchangeable sodium, the total body water, and sodium space were measured in patients with congestive failure, cirrhosis, and in normal individuals. The mean values for total body water (antipyrine volume) were slightly increased in the patient group. The total exchangeable sodium was increased above normal in both patient groups as determined by the distribution of $Na^{22}$. In hyponatremic patients, the exchangeable sodium did not differ significantly from that of the patients with cirrhosis or heart failure having normal serum sodium values. The radioactive sodium space paralleled the findings for exchangeable sodium. The mechanism by which hyponatremia developed in these patients is not clear. Overhydration does not appear to be the explanation because of the normal or only slightly increased body water and increased exchangeable sodium values. The possibility of transfer of sodium into tissue depots such as bone and connective tissues is discussed.—C. R. SHUMAN

**Dietary Habits in Uttar Pradesh in Relation to Income.** K. K. Govil, D. P. Bhatnager, and K. C. Pant. *J. Indian M. A.* 26: 138, 1956.

The relationship of dietary habits to income level was studied in 238 families comprising 1,489 persons for the years 1952 to 1954. Close and careful investigation revealed that with an increase in income the consumption of wheat, fruits, vegetables other than green leafy ones, sugar, ghee, and milk increased. The caloric intake improved, as did the consumption of protein, fat, calcium, and most of the vitamins. The animal protein intake was relatively poor in all income levels in this area of India. The total food expenses did not increase in proportion to the income.

Poverty, ignorance, religious objections, tradition, and scarcity of protective foods are causes of deficient diets. To produce 1000 calories in the form of milk, meat, and most vegetables requires more land than to produce 1000 calories as cereals and root crops. The authors conclude that the higher income levels are not always associated with qualitative dietary improvement, and that proper education should improve matters. Although the study was performed in rural India, the findings are probably similar to many urban areas in the United States.—S. O. WAIFE